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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. II May, 1918 No. 5

The ARRANGEMENTS FOR THE SUMMER MEETING AT DAYTON, OHIO

JUNE SEVENTEENTH AND EIGHTEENTH

RESERVATIONS for the Orville Wright dinner at the Dayton meeting are now (May 22) well over the five hundred mark, so that as far as attendance goes the success of the meeting is already assured. As already announced, the meeting will be held on Monday and Tuesday, June 17 and 18. The Standards Committee meeting and Sections conference will take place on June 16 at the Engineers Club, the former at 10 a. m. and the latter at 8 p. m. President Kettering will act as toastmaster at the dinner, Governor Cox of Ohio has given a tentative promise to make an address, and other speakers with up to the moment messages will be on hand.

Information Bureaus

Arriving at Dayton S. A. E. members will find a bureau at the Union Depot where information in regard to accommodations, meeting arrangements and to Dayton itself can be obtained.

Another bureau of information will be maintained at S. A. E. headquarters at the Miami Hotel. The registration of all members and the distribution of badges will take place in the small building at the entrance to Triangle Park. Arrangements are being made to serve luncheon to the members at the Park on both Monday and Tuesday, so that they can go out there in the morning prepared to spend the day. If there is a demand for it, a dinner will be served at the Park Tuesday evening.

Several applications have been made for dinner reservations for ladies, but owing to this being a business and war session it has been decided by the Meetings Committee that the meeting and dinner will be exclusively for men, the same as the Summer Meeting held in Washington a year ago.

Professional Sessions

The professional features are now well in hand and a number of important papers and addresses will be presented. These will relate to a wide diversity of subjects, among them being the refining of petroleum, aeronautic engineering, tractor engineering, design of heavy fuel engines, etc. W. B. Stout will discuss Present Day Problems in Aeronautics, Fay B. Faurote will talk on Airplanes of Today, and F. W. Caldwell will give a paper on propellor design. It is expected that a comparison of modern aviation engines will be made by someone at McCook Field, this to be based on the foreign engines now at Dayton, which will be available for inspection by those attending the meeting.

Reports on the recent International Aircraft Standards Conference will be presented by E. H. Ehrman and by General Manager Clarkson, who attend it on behalf of the Society and have recently returned to this country.

An interesting paper on the Processes of Petroleum Refining is to be presented by C. W. Stratford. It will be illustrated by an exhibition of actual refining methods. A symposium on heavy fuel engines for automotive purposes will be participated in by P. L. Scott and C. E. Sargent.

A separate session devoted to tractor engineering will be held and it is expected that papers will be presented on fundamentals of tractor design, and on the design of farm implements and machinery for use with tractors.

Automotive Exhibitions

Arrangements are practically completed for the exhibition of automotive military apparatus. Dayton itself furnishes plenty of aeronautic material. The formation and night flying will be conducted by machines from the fields near the city.

The McCook Field collection of foreign engines from France, England, Italy and Germany will probably be shown to the members at Triangle Park.

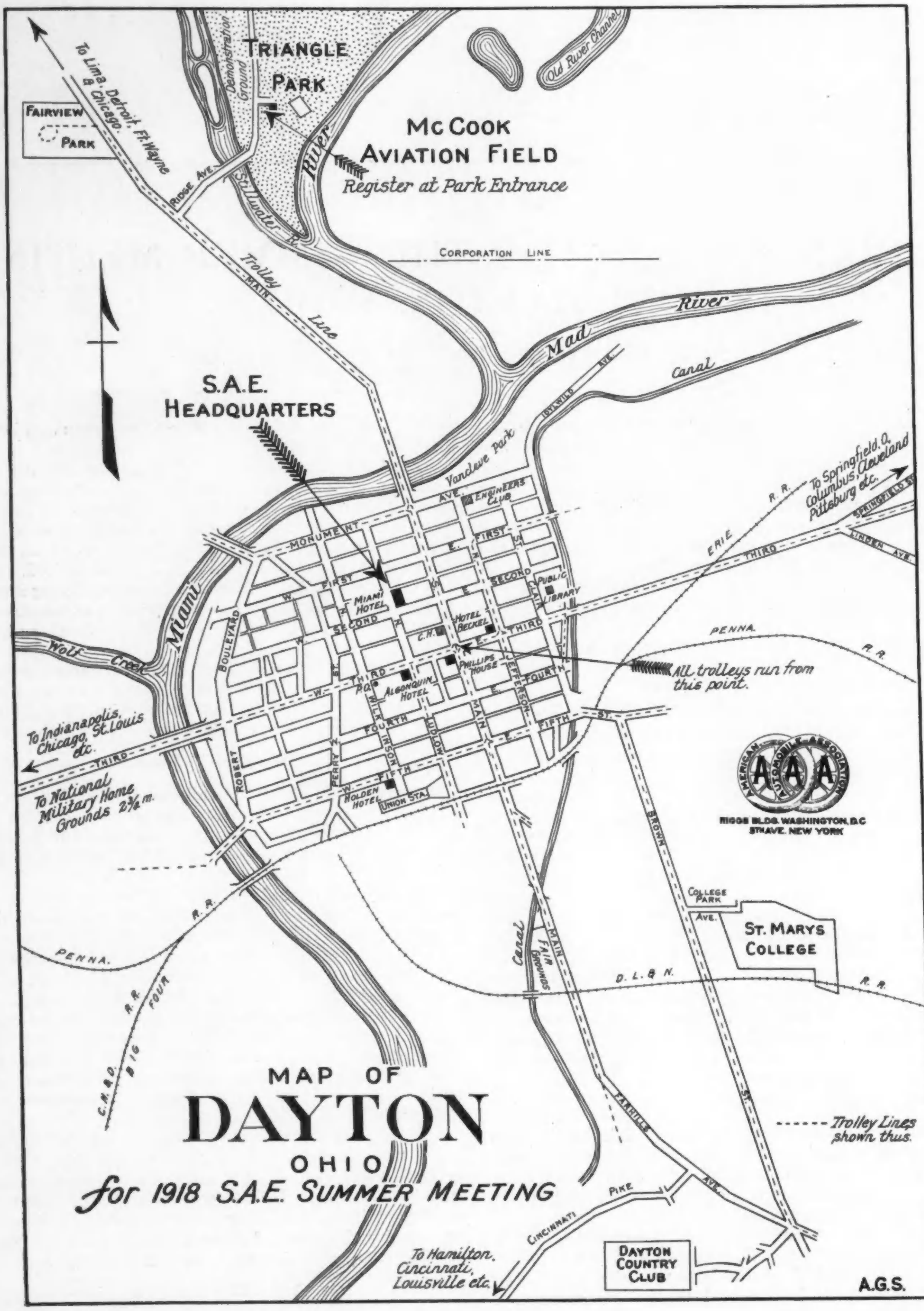
It is also hoped to have a captive balloon such as is used on the other side for directing artillery fire. If possible, foreign aviators will be on hand to give exhibitions of the fighting maneuvers used at the front.

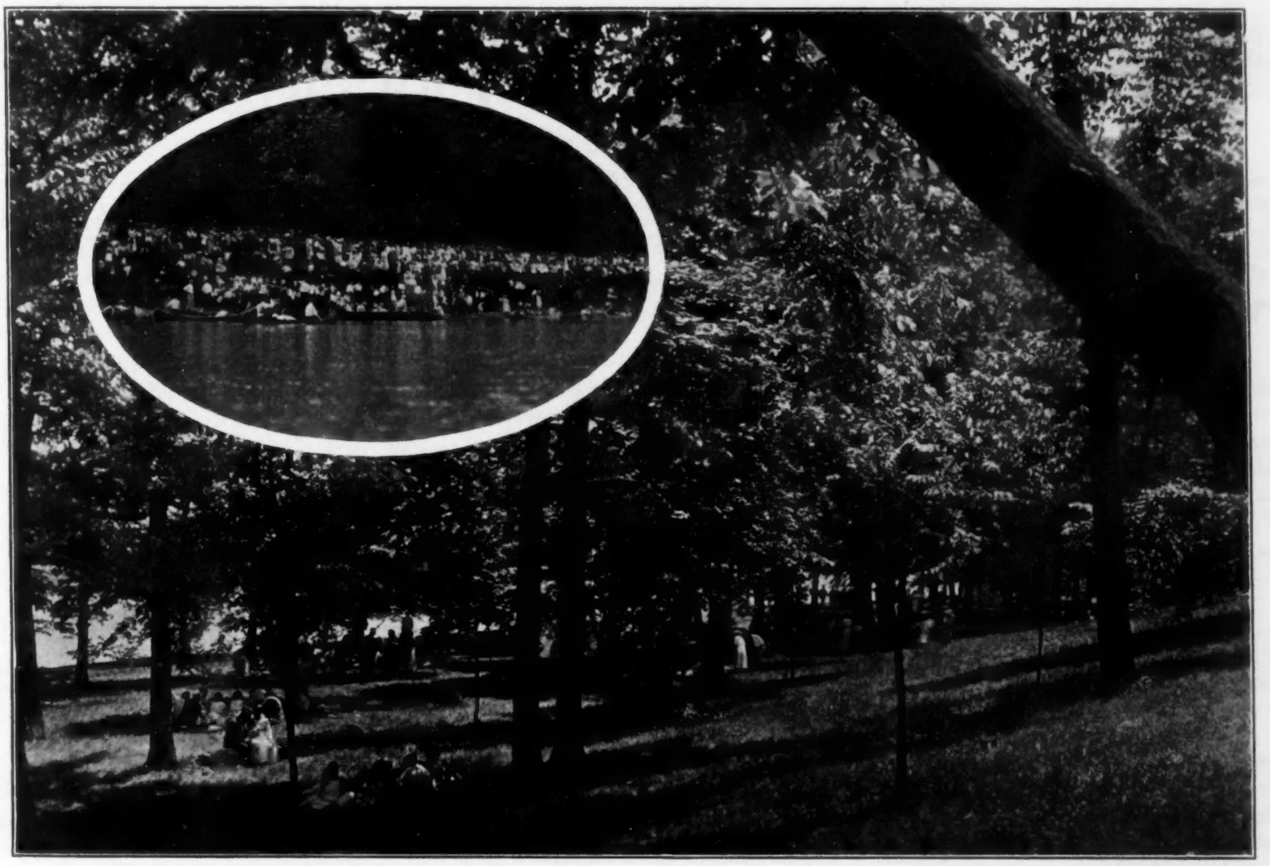
The ordnance apparatus will probably include four-wheel drive trucks, tracklaying types of tractors, while from the Quartermaster's Department it is hoped to get some examples of the latest designs of military trucks and motorcycles.

The railroad service into Dayton is somewhat limited at the present time on account of Governmental control, so that members should make their reservations to the city at once. It is hoped that a large number of members will be able to drive to the meeting, thus helping to solve the railroad transportation problem. Special parking space at Triangle Park will be assigned.

Committee Personnel

The general arrangements for the meeting are under the supervision of the Meetings Committee of the Soci-


MAP OF
DAYTON
OHIO
for 1918 S.A.E. SUMMER MEETING
TRIANGLE PARK
McCOOK AVIATION FIELD
Register at Park Entrance
S.A.E. HEADQUARTERS
All trolleys run from this point.
To Lima, Detroit, Ft. Wayne & Chicago.
To Springfield, O. Columbus, Cleveland Pittsburg etc.
To Indianapolis, Chicago, St. Louis etc.
To National Military Home Grounds 2⅜ m.
To Hamilton, Cincinnati, Louisville etc.
FAIRVIEW PARK
CORPORATION LINE
Trolley MAIN Line
Mad River
Miami
Wolf Creek
Canal
Old River Channel
Stillwater
ENGINEERS CLUB
MIAMI HOTEL
HOTEL BECKEL
PUBLIC LIBRARY
PHILLIPS HOUSE
ALGONQUIN HOTEL
HOLDEN HOTEL
UNION STA.
ST. MARYS COLLEGE
COLLEGE PARK AVE.
DAYTON COUNTRY CLUB
CINCINNATI PIKE
FARHILLS AVE.
BROWN ST.
PENNA. R.R.
ERIE R.R.
D. L. & N. R.R.
C.H.&D. BIG FOUR R.R.
Trolley Lines shown thus.
RIGGS BLDG. WASHINGTON, D.C
5TH AVE. NEW YORK
A.G.S.



View in Triangle Park Looking Toward Miami River. Insert Showing the River Bank

ety, consisting of David Beecroft, chairman; Herbert Chase, Fred E. Moskovics, F. E. Place, and C. F. Scott. Mr. Chase is handling the securing of papers, Mr. Place the general arrangements, Mr. Scott the dinner details, and Mr. Moskovics will supervise the reception of guests.

The Dayton S. A. E. Committee will handle many of the details at that end, and will help members to secure accommodations in case they have any trouble in doing it themselves. Of this committee, Orville Wright is honorary chairman; Vincent G. Apple, chairman; F. H. Hoover, 137 No. Ludlow St., Dayton, secretary and treasurer. The other members are: Capt. Howard Blood, F. J. Blose, Carl Buest, John F. Huffman, W. B. Stout and I. B. Swagles.

RURAL MOTOR EXPRESS LINES

FULL use of motor trucks operating on the highways and a great increase in the operation of rural motor express routes are the objects of a campaign of information and encouragement that has been started by the National Motor Truck Committee of the National Automobile Chamber of Commerce.

Patriotic desire to stimulate food production and develop practical means of getting it to market is the motive of the committee which has organized for the purpose a special department under the direction of S. A. Miles, with headquarters in the offices of the N. A. C. C. at 7 East Forty-second Street, New York.

An investigation of existing rural motor express lines made by the Highways Transport Committee of the Council of National Defense has produced conclusive evidence that they are of great utility to farmers and rural merchants, that they encourage increased production of food by assuring quick and regular daily means of shipping to market, and that there are possibilities throughout the country for the establishment of many more similar lines with assurance of success where conditions are favorable.

As a result of this investigation the automobile industry has tendered its enthusiastic support of the movement as a patriotic duty. Manufacturers and dealers will at once be asked by the National Motor Truck Committee to cooperate by searching in their respective localities for routes over which motor express lines may be started and along which the rural population seems to justify expectation of profitable operation. They will also be requested to induce men to place trucks in such service to assist prospective operators in the selection of routes and with advice as to details of operation and management of the business. Mr. Miles' department will supply information along these lines to be disseminated by the dealers.

Pioneer Automobile Development

By PRESCOTT WARREN* (*Associate Member*) METROPOLITAN SECTION PAPER

THE conception of a self-propelled vehicle, of what we today call an automobile, is one of the oldest in human annals. It is probable that that revolutionary being who, when mankind was emerging from savagery into barbarism, first applied the wheel to a vehicle, had vague glimpses in his mind of an occult power which would propel that vehicle without the aid of man or animal.

All through the myths and legends of the ancients we find conceptions of the self-propelled vehicle, that swift, silent, mysterious carriage which would transport them with speed, comfort and safety on the land or in the air. But so remote did this seem, so far beyond the grasp of mankind, that the ancients had not the audacity to claim it for themselves even in their legends and myths, but attributed it to the gods.

As the Egyptians, the Persians, the Greeks and the Romans attained their high degrees of civilization the desire for this godlike device became more and more persistent. Civilization realized instinctively that somehow mechanical forces could be set to work to annihilate time and space, but throughout ancient times the wish remained only a wish.

Leonardo da Vinci's Self-propelled Vehicle

The first record of a concrete human conception of a self-propelled vehicle is found in the fifteenth century, when Leonardo da Vinci, one of the greatest, and certainly the most versatile, of geniuses that ever lived—poet, philosopher, architect, sculptor, painter, engineer, statesman, warrior—conceived a military vehicle propelled by steam for assaulting the walls of fortified towns. It was, in effect, what we would now call a tank. Leonardo not only conceived it, but designed it, and although he never built it he left a full set of drawings of it. Modern engineers have examined his drawings and have found that it is entirely practicable, that it could be built, and could be made to run.

Early Attempts to Run Self-propelled Vehicles by Steam

The first real impetus toward the attainment of civilization's most crying need came with the invention of the steam engine in the last quarter of the eighteenth century, less than 150 years ago. More progress has been made in swift transportation in that period than in the sixty centuries of recorded history before it. Immediately upon the discovery of this new force earnest attempts accompanied by heart-breaking failures were made to adapt it to propelling land vehicles. The attempts became so numerous, in fact, as to attract the bitter opposition of the Tory or reactionary element in every country, that element which always wishes to let well enough alone. The opposition was so effective that it resulted in legislation ruling such vehicles off the road. It has been said, and probably truly, that this legislation set back the development of the automobile, and thereby the advance of civilization, by a full century.

Let us pause here to pay tribute to the indomitable perseverance of those hardy pioneers—business men and engineers—who, when they found themselves ruled off the highways, had the audacity to conceive of buying their own rights of way, building their own graded roads and laying rails upon them, and thus set the beginning of our modern railroad system; who not only had the imagination to conceive this stupendous thing, but who had the courage to put their capital into it, and the brains to execute it.

Perhaps we should pay even higher tribute to those other pioneers, those other industrial radicals, who foresaw that the self-propelled vehicle running on rails on a graded road, on a private right of way, would not, by any means, even begin to meet civilization's crying demand for a vehicle that any individual could drive himself, wherever he wished, on a public highway. Luckily, nature endows certain men in every epoch with that pioneer instinct which impels them in the face of laws, ridicule and mechanical discouragement, to achieve the seemingly impossible.

Automobile Development Retarded by Legislation

I have said that it is probably true that legislation set back the development of the automobile by a full century. Some exception may be justly taken to that statement. Remember, the first automobiles burned hard fuel —first wood and then coal—and they ran on steel tires. But the automobile as we conceive it today—a vehicle to transport us on the highways with speed, comfort and safety—awaited two things—liquid fuel and the pneumatic tire. Neither was available for many years. It may be permissible to discuss them in the order not of their advent, but of their importance.

The automobile would be well-nigh impossible without the pneumatic tire. We cannot conceive of its widespread use without this which seems at first glance a mere accessory. It is only twenty-five years since the pneumatic tire was invented. But in that short time the automobile has revolutionized our social and economical life, and its manufacture has become America's third greatest industry.

Discovery of Liquid Fuel

The automobile was also of little value without liquid fuel. We, today, cannot conceive of putting up with wood or coal.

Liquid fuel was discovered about 1860. One of the first pioneers to experiment with it discovered that it had explosive as well as inflammable properties.

Another soon conceived the brilliant and almost revolutionary thought of inducting a gasified drop of liquid fuel into the cylinder of an engine, exploding it there,

*President, Stanley Motor Carriage Company.

and allowing the resulting force to drive the piston down.

This was *power direct from fuel.*

The Fork in the Road

Here lay the fork in the road. The pioneers saw before them now two paths, each apparently beckoning them to their goal. Remember, up to this time all experiments on self-propelled vehicles had been with steam. What motives were these, then, which lead the engineering fraternity down the wrong fork?

Unquestionably the lure of getting power direct from fuel was foremost.

"Why burn fuel under a boiler, transfer the heat to the water to turn it into steam, and then conduct the steam to a cylinder, when the fuel itself could be burned (exploded) directly in the cylinder, thus dispensing with the steam boiler and burner units altogether?" The thought seemed brilliant and feasible. It aroused the spirit of adventure—the instinct of the pioneer—in the engineers of the day.

Explosive Engine Characteristics

For certain purposes, indeed, it has great merit—for stationary engines and such purposes as require only constant power and constant speed.

But engineers at once began to adapt this new engine, essentially a constant-speed, constant-power device, to the variable-speed, variable-power automobile—which is, perhaps, the most inappropriate use to which it could be put.

Patent Protection

Steam practice, even at that day, was highly standardized. Indeed, for self-propelled land vehicles, driven by steam, Stephenson's types of boiler and engine are today the standard. There was scant hope, therefore, that the engineer could develop anything in the steam line so revolutionary and so advanced that he could secure patent protection. But he could see in this new, unknown, untried device, so simple in theory and so alluring to his inventive instincts, a splendid opportunity to be the first to hit upon that secret in harnessing it to the automobile, which might be so basic as to give him complete patent protection, and yield him an enormous fortune.

And as each engineer heard rumors of what other engineers in other parts of the world were doing this only spurred him on to swifter action, and encouraged him to think that if these others were struggling along the same path, it must surely be the right path.

It was immediately apparent that a clutch and a change-speed gear had to be interposed between the engine and the rear wheels. But such problems did not deter these courageous pioneers, nor did the more delicate problems of vaporization, carburetion, and ignition. Persistent inventive genius, following the engineering fashion which had set in, combatted the difficulties and almost overcame them. Nor did the engineers hesitate long to duplicate their internal-explosive engine, or quadruplicate it, or to put in six or eight or even twelve cylinders to drive one automobile.

Is not the theory of the internal-explosive engine as applied to a variable-power, variable-speed device like an automobile fundamentally a fallacy? The manufacturer of today will say he builds gas cars because the public wants them. The automobilist, who knows only what the manufacturer has taught him, will insist that gas cars must be better because there are more of them —that if steam cars were better the manufacturers would build steam cars. So the manufacturers blame the fashion upon the public, and the public blames it upon the manufacturers.

Internal-Explosive Engine Complications

Those early pioneers were really to blame—those who began with the beginnings of the explosive liquid fuel. They were carried away with the idea of getting "power direct from fuel." And they lost sight entirely of the fact that their real problem was not merely to get the power from the fuel, but to get the power from the fuel to the driving wheels of an automobile, which device, above all others, requires instantaneous variability of power, and instantaneous response to the driver's will. The complications introduced to make the internal-explosive engine deliver its power to the rear wheels became in time, indeed almost immediately, far greater than those of the steam boiler and burner units, which, with the best intentions in the world, the pioneers had undertaken to get around.

Clutch, gearshift, complete electric plant for ignition, and another complete electric plant for starting the internal-explosive plant, flywheel, accelerator, jointed drive shafts, carbureter—these complications are a splendid tribute to the "persistent inventive genius" which created them.

The intelligence applied to the problems was of the highest order, save that it was short-sighted. Instead of trying to find an easier road to their goal, instead of remembering that fork which they had passed, the pioneers persisted on the path they had selected, with just enough success each year to urge them forward. And now it is perhaps not too much to say that they have penetrated so far that they find themselves in the midst of a vague. Today some of those who are more courageous, are beginning to think for the first time of the other road, and to give an occasional glance at the lone voyager who has come so much nearer giving to the public that performance which it has always demanded and is still demanding.

Stored Power an Advantage of Steam Cars

The secret of the performance of the real steam car lies in its stored power. We have in mind a certain type of steam car, once most conspicuous, which had none of it and which was abandoned for the internal-explosive type. With its flash boiler, it was necessary, as in a gas car, to create the power after the need for it had arisen.

This involved control mechanism as delicate and complicated as in a gas car, including even a gearshift and a clutch. It is obvious, therefore, that with no better performance than the gas car with which it competed, there was no excuse for it.

We can only assume that its manufacturer, intent upon giving the public what he thought it wanted, and finding unconventionality yielding no superiority in performance, decided to proceed along the line of least resistance.

The industrial history of the world records many an earlier example of an "engineering fashion," which has carried engineers and the public far down the wrong fork in the road.

The electric industry once suffered from a similar fundamental error. In the early days, the alternating current was the vogue, only to be forced by an "engi-

neering fashion" to give way before the so-called "direct current." The very words, like the phrase "power direct from fuel," cast a spell. For a decade or more one lone figure, S. Z. DeFerranti of London, championed the alternating current. It was he who, in the face of sneers and ridicule, kept the faith alive through 20 years. In 1889 another great radical, George Westinghouse, took up the fight and began a vigorous campaign of exploitation. These two courageous men lived to see the world turn again to the alternating current. The "fashion" for direct current died out and the alternating current succeeded it, not as a mere change of fashion, but because it was fundamentally sound, because it delivered a superior performance.

Difficulties with Internal-Explosive Engines

It is highly probable, if those early automobile engineers could have seen the latest products of their most brilliant successors, with eight or twelve cylinders; with standardization so remote, even in this respect, that the oldest manufacturer of cars in America admits that twelve cylinders are necessary for a good performance, and the most successful claims that four are enough; with over three thousand revolutions a minute and the resultant lubrication problems; with the engine removed to the farthest possible point from the driving wheels; with two or even four universal-joints; with incredibly delicate vaporizing mechanism; with incredibly accurate manufacturing limits; with even four valves to a cylinder controlled by incredibly accurate timing gears; with the primitive functions of clutch and gearshift still present—it is highly probable that those early engineers, if they could have visualized the modern automobile, would have cried to one another, "Hold! We dare not impose so prodigious a tax upon the brains of engineers. We dare not impose so prodigious a mechanism upon the civilization we are striving to benefit."

But entirely aside from the complications of these later days, entirely aside from the initial and well-nigh prohibitive practice of making a firebox out of the cylinder, the error was fundamental.

There is no stored power in an internal-explosive automobile—there cannot possibly be any. The only place where power can be stored is in the flywheel, and it can be stored there only by speeding up the engine after the emergency calling for the power has arisen.

Only in the steam car and in the electric car can power be stored.

The electric car would be ideal, and would probably displace both steam and internal-explosive cars but for its four principal limiting factors—its range of operation is too short; it takes hours to restore its power; it lacks a forty or fifty-mile-an-hour spurt; and the driver is conscious every minute that he has less power than he had a minute before.

Stored power is necessary for any self-propelled vehicle, on rail or road, for the performance the public wants and must have.

The modern internal-explosive engine is a marvel of ingenuity. "Persistent inventive genius" has done wonders in combating the difficulties which are inherent in it.

But no matter how well the work is done or shall be done, the results the engineers are striving for, the performance the public is demanding and must have, can never be attained with this form of power.

It cannot be attained with electric power, owing to the prohibitive limitations outlined above.

It can be attained now, without any limitations, and with the most conventional, the oldest, the most highly standardized, the most efficient, the safest, the simplest and the least mysterious powerplant that science has ever devised for driving a land vehicle.

Attributes of the Ideal Car

We want to make, we want to sell and we want to drive a car whose whole range of power is controlled by a little finger lever on the steering wheel; whose gears are always in mesh, so that we never have to separate the power from the load in order to change the car speed—especially when we are compelled to do it unexpectedly in dangerous places, on Fifth Avenue, on Rush Street Bridge or in the mountains.

Whose power is built up in advance ready for instantaneous application to the rear wheels at our merest wish.

Whose power does not depend upon the speed of a flywheel, which can be accelerated only after the critical emergency has arisen.

Whose maximum torque can be applied to the wheels under the most adverse conditions, giving fullest efforts at lowest speeds—at one mile an hour if the hill or mud requires it—without relation to the speed of the engine.

Which has only two cylinders, and a crankshaft only 8 in. long, and yet has 100 per cent torque on the crankshaft continuously, without "impulses"—without even "overlapping impulses."

Whose crankshaft is parallel to the rear axle so that no right angles must be turned by the power.

Whose engine is at the nearest possible point to the driving axle—geared to it, in fact, so that no jointed drive-shafts are necessary.

Which has only thirty-seven moving parts in the complete vehicle.

Whose power is not created by turning the engine cylinder into a firebox, but is generated with no moving parts to be exposed to the heat and the gases.

Whose power can be built up without operating the engine, or whose engine can deliver this power without waiting for combustion.

Whose fuel is supplied for consumption without the aid of a carbureter or other outside atomizing or vaporizing device.

And whose fuel is kerosene.

If the engineers of the industry accept these as the attributes of the car they want to make, to sell and to drive, then we will accept the responsibility of affirming that they can be had only with steam.

As soon as the public realizes that these attributes are to be had in an automobile, and that the limitations of the internal-explosive engine have already been reached without yielding them, the manufacturers must abandon their present powerplant and substitute therefor the steam boiler and burner. The boiler will be of the fire-tube, water-level type, to permit great storage of power; and the burner will be equipped with a pilot to maintain that power when standing.

These, we think, are the attributes of the performance which all automobilists want and all manufacturers are trying honestly to give.

This, we think, is akin to the performance which the early pioneers hoped for, and courageously set out to attain.

This, we think, is akin to the vehicle which the ancients dared not even to desire for themselves—the vehicle which to them was worthy only of the gods.

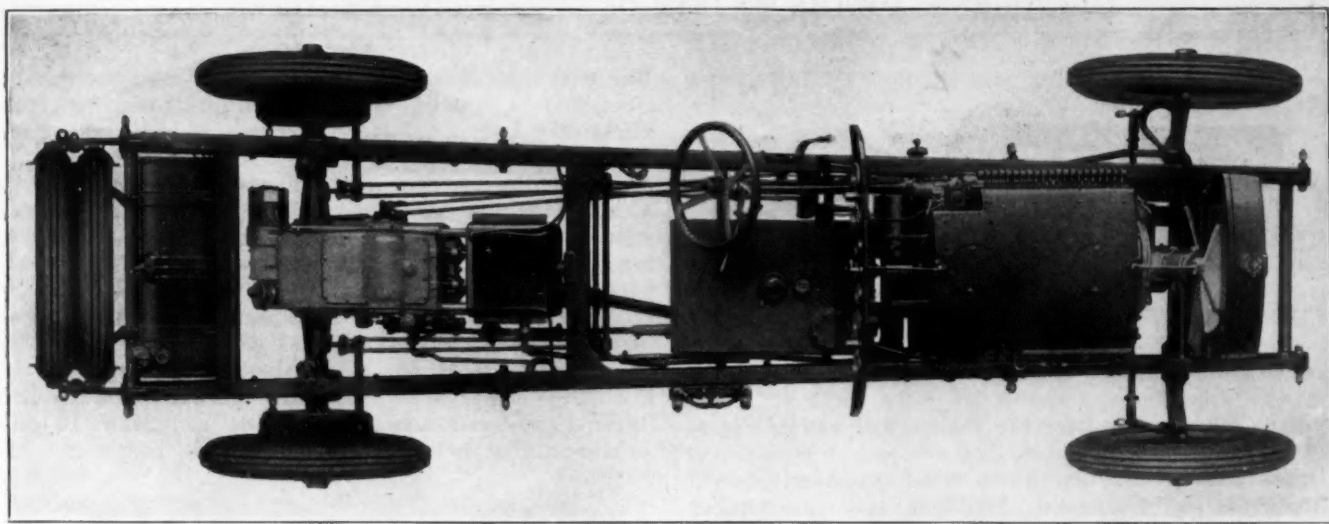


Fig. 1—Chassis of the Doble Steam Automobile Showing Positions of Powerplant Units

Electrically-Controlled Steam Automobiles

By ABNER DOBLE* (*Non-Member*)

METROPOLITAN SECTION PAPER *Illustrated with* PHOTOGRAPHS

THE first actual attempt at driving a vehicle by steam seems to have been made in 1770 by Cugnot. A single wheel in front served as a steering and driving wheel. A pair of cylinders acted upon a crankshaft which was geared to the rear axle. The boiler was located in front of the engine, and both boiler and engine overhung the front wheel. This vehicle was capable of making a speed of $2\frac{1}{4}$ m.p.h., but was unmanageable because of steering difficulties. The original model is preserved in the Conservatory Des Arts et Metiers, in Paris.

The first authentic record of a power-propelled vehicle is found in a patent taken out by Watt in 1784, which describes the application of a steam engine for the purpose of locomotion.

Speedily following this, in 1786, a steam carriage was built by Murdock, Watt's assistant, and was run upon the high road near Redruth, Cornwall.

Similar experiments were made by William Symington, to whom the idea probably occurred at about the same time as to Watt.

Oliver Evans, an American inventor, likewise constructed a steam vehicle in 1787, and obtained rights to operate steam vehicles in Pennsylvania and Maryland.

Some years later (1802) other attempts were made by Trevithick and Vivian in England, but were shortly discontinued, probably owing to the generally poor condition of the roads, or to the attraction of enterprise and capital to the improvement of railroads, the introduction of which had been begun.

For about thirty years the subject was in abeyance, when it was revived again by Griffiths, Brunel, Gurney and Hancock. The steam carriages constructed by these inventors were run in various parts of England and Scotland, but their operation did not prove profitable commercial undertakings. In 1839 Hancock built and operated several steam omnibuses in the city of London and the suburbs.

The latter type of vehicle, when carrying supplies of water and fuel, but without passengers, weighed about $3\frac{1}{2}$ tons. In general it attained a speed of 10 m.p.h., but on exceptionally good roads was capable of a speed of about 20 m.p.h. However, prohibitive tolls were extorted on the turnpike roads and road laws passed which provided that a man had to walk in front of a car waving a red flag, so that finally the operation of steam vehicles was practically stopped.

Not until 1889 was there a substantial revival in motor-driven vehicles, and from that time on rapid strides were made in the development of the so-called horseless carriages.

Serpollet had been experimenting for some years in France, and produced some efficient machines, the boiler being of the flash type, using gasoline or kerosene for fuel. The fuel was first vaporized, by means of a cup charged with alcohol placed beneath the burner, which served to heat the lower part of the coil. The vapor from the fuel in the heated coil passed to the base of the burner, where air was introduced with the vapor, the resulting mixture being ignited by the preheated coil in passing upward. The coil was then kept hot by the continuous burning of the fuel and likewise continued to vaporize the fuel as it was fed through the coil.

Early Steam Car Builders

Among the early builders of steam automobiles in this country may be mentioned the Baldwin Automobile Company, Providence, R. I.; the Milwaukee Automobile Company, Messrs. F. E. & F. O. Stanley, the Locomobile

*Vice-President, Doble-Detroit Steam Motors Company.

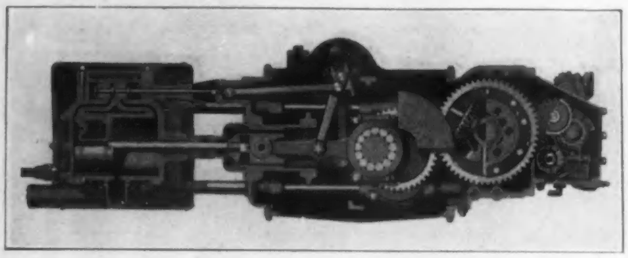


Fig. 2—Cross Section of Doble Engine
Generator gear meshes with main drive gear on rear axle

Company, and a little later the White Company of Cleveland.

In the early nineties a wave of progress spread throughout the Continent, England and the United States, which started the development of the internal combustion engine, as well as the electric motor for road vehicles.

In the steam car several great disadvantages had presented themselves. One was the low mileage that could be obtained from the amount of water that could be carried conveniently. It was most uncommon to be able to make a continuous run of one hundred miles without refilling the water tank, and in general, it was necessary to stop for water every twenty-five to fifty miles of travel. Another serious drawback was the trouble and time required in starting. If a steam car could be gotten under way in ten to fifteen minutes from a cold boiler, it was considered most satisfactory. Ordinarily it might require a half hour and the manipulation of various manual devices, which demanded an intimate knowledge of the mechanism of the car. A great deal of the delay in starting was due to the preheating of the main burner by means of a pilot light, which first vaporized the fuel in the primary burner. Also there has always been an element of danger from the exposed flame of a pilot light when gasoline is used.

About ten years ago steam cars had reached a high state of popularity and had a large number of enthusiastic advocates, since two companies—the Stanley and the White—were producing them in quantities. Under these conditions and in an industry which was bound to assume such huge proportions, it was most natural that experiments should be made with other sources of power besides steam.

At the time of this early development in automobiles even the long established prestige of the stationary steam engine seemed to be somewhat in jeopardy, and a number of large engine builders began to think of the possibility of steam being replaced by the explosive type of engine. A great deal of attention was being given to the perfection of the gas engine for stationary plants. In such service the problem of the ignition of fuel and the generation of steam did not enter as a factor, as it does in the application of a steam generating plant for an automobile.

It was most natural, therefore, that automobile engineers should and did turn their attention almost entirely to the perfection of the internal combustion engine. Development along this line progressed most satisfactorily, and one by one the manufacturers of steam cars changed over, and with the exception of those of the Stanley Company, no steam automobiles have been in regular production for the past six years.

Every engineer will agree that steam is the most dependable and the most flexible source of power. To approach that smooth running, positive power in a gasoline car, the tendency has been to increase the number of cylinders, until we now have in common use many eight and twelve-cylinder internal combustion engines. Other methods have also been employed, such as increasing the number of valves and combining the gasoline engine with the electric motor. All of this practice tends to complicate the mechanism and to increase the fuel consumption in the effort to secure the performance obtainable with the steam engine.

During my ten years of experimental work I have always had in mind the possibility of overcoming the objectionable features and seemingly insurmountable difficulties that had diverted development from steam to internal combustion engines for the propulsion of automobiles. The principal problems that confronted me were:

1. The low mileage possible on one tankful of water.
2. The formation of scale in the boiler with a resultant drop in efficiency and added liability of burning the already extremely hot heating surface, which in turn necessitated the frequent cleaning of the boiler.
3. The toil, time and inconvenience involved in firing up the main burner by means of a pilot light.

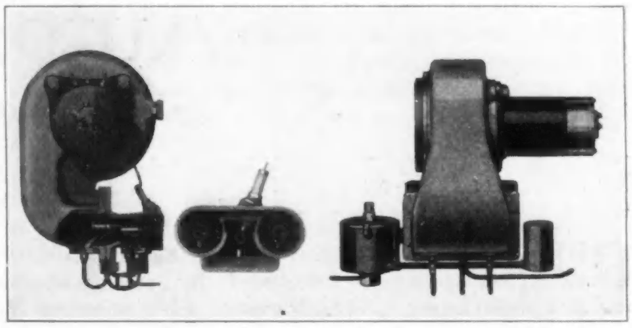


Fig. 3—Blower, Motor, and Cross Section of Fuel Nozzles
The starting nozzle is forward and the two running nozzles are side by side slightly behind the starting nozzle

If the ignition and starting of a gasoline car could be accomplished almost instantly by the operator sitting at the steering wheel, why could not the same result be obtained in a steam car?

Electricity is a refinement now used for ignition of and starting the steam car. The driver can sit at the steering wheel, close the switch on the steering column, and his car will start in a minute's time, even though the car may have been standing idle for several hours.

At extremely low temperatures, with the generating system cold, it will require about two to three minutes to start the car, but from the time it begins to move, smooth, even power is had, and there is not from five to ten minutes of bad running as is the case, until the engine warms up, in a gasoline car.

One filling of the water tank, holding 25 gal., will suffice under ordinary conditions for upwards of 2500 mi. of running. One filling of the 25 gal. kerosene tank insures from 250 to 260 mi. of travel.

The simplicity of construction and operation of the present-day steam car makes the predominant features of electrically-controlled steam most apparent. The automatic controls are so simple in construction and so positive in action that almost no attention need be given them.

The moving parts in the steam-car mechanism are about one-half the number of moving parts required in a six-cylinder gasoline car. That means less worry and less upkeep expense.

These accomplishments have been the result of exhaustive experiments to determine the most efficient and most adaptable type of boiler to use. I was able to profit by the experience of others who had already done a great deal of good work toward perfecting the application of the flash and fire-tube types of boilers.

Six years were spent in building and testing experimental steam powerplants, which resulted, late in 1913, in trying the combination of a water-level type of boiler with a honeycomb radiator to condense the exhaust steam. The theory was that in order to obtain the necessary cooling surface this type of radiator furnished the best possibilities for obtaining an adequate distance upon one supply of water. The results were most gratifying. The car would run from 1000 to 1500 mi. on 24 gal. of water.

The honeycomb radiator furnishes about six times the cooling surface of any other type of equal size, but the selection of this type had previously been deemed unwise because the heavy molasses-like oil used in steam engines clogged up the extremely small radiator passages, and the exhaust steam, particularly when a flash boiler was used, was liable to melt the soldered joints of the radiator. It was my belief that the use of a heavy oil was not essential.

In a steam automobile little lubrication is required for the cylinders, as the piston speed is low at ordinary driving speeds, and the cylinder surface, being cast iron, is easy to lubricate.

The presence of moisture in the steam during expansion goes a long way toward the proper lubrication of the cylinders and valves. The cylinders in a steam car will be much more easily lubricated when moist steam is used for the driving force than in an internal combustion engine when hot gases furnish an explosive impulse within the cylinders. For these reasons it was determined to try ordinary gas engine cylinder oil, and from the first it proved entirely satisfactory.

Development of a Steam Generator

Attention was next given to the development of a satisfactory steam generator. The water-level type of boiler, which had been used successfully in conjunction with an improved condensing system, possesses a number of the essential qualities required; it holds the temperature of the steam practically constant with no danger of sufficiently high exhaust temperatures to melt soldered joints or effect an undesirable change in the lubricating oil. It always keeps a large reserve of water heated to the steam temperature, which gives it steaming stability and admits of great acceleration. The heat-transference conditions make for efficiency, owing to the extremely short distance through which the gases of combustion radiate their heat to the tube walls.

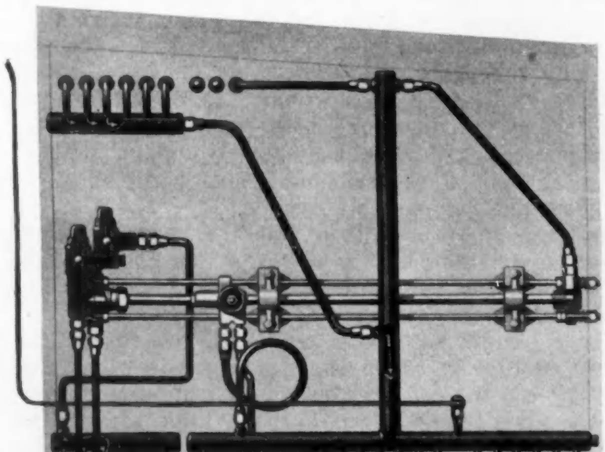


Fig. 4—Water Level Regulator
When tube is filled with water, needle valve opens owing to contraction of tube; water from pumps is by-passed to water tank

On the other hand, the fire-tube boiler which we first tried had its disadvantages; it was heavy and costly to manufacture, since it had to be wound with a mile of piano wire to minimize the potential danger present in a large-diameter shell. It was liable to leaks, which might be caused even by overheating with low water or by oil working through the expanded joints where the tubes were fastened into the heads.

The flash type of boiler was out of the question, but it had certain good qualities. The direction of the water flow opposite to the flow of the gases of combustion was a great advantage, in that it allowed the water to extract, as far as possible, the last remaining thermal units.

The long period of experimentation has resulted in our present steam generating system, which is similar in theory to the flash boiler, yet in appearance is more like the water-tube boiler, having a water level in the evaporating zone. It consists of twenty-six sections placed in a planished steel casing insulated with Kieselguhr. Each section is made of cold drawn seamless steel tubing of 3/4-in. diameter, No. 16 gage metal. Twenty of these sections are used for the generation of steam, and the remaining six are the preheating, or economizer sections. The generating sections consist of twenty vertical tubes connected top and bottom by horizontal headers. The vertical tubes are swaged at both ends to about three-eighths of an inch, and are welded into the horizontal headers by the autogenous acetylene process, thereby making the section in effect one piece of steel and actually stronger at the welded joints than in the tubing itself. The six economizer sections are like the generating sections, except that they have sixteen vertical tubes in place of twenty.

The generator is designed for a working pressure of 600 lb., and the safety valve is set for 1000 lb.; each section is tested to withstand 5000 lb. pressure. When sections have been subjected to a destructive test in laboratory experiments, observations have shown a rupture of a tube would only occur at cold water pressure ranging from 8000 to 9500 lb., and when a rupture did occur it was invariably at a point remote from the welds.

Directly below the generating sections is the combustion chamber, and below the economizer is the exhaust for the gases of combustion. A bridge wall of Kieselguhr divides the two sets of sections. A manifold, through which water enters, connects the lower headers of the economizer sections. The water leaves by a similar manifold at the top and is led to a manifold connecting the lower headers of the evaporating sections. The steam leaves the upper headers and is conducted through a fourth manifold to the throttle valve.

Besides being absolutely free from any danger of explosion a boiler of this construction can be manufactured cheaply, and any damaged section can either be easily and cheaply replaced, or be isolated in a few minutes by blanking it off until it can be replaced. The excellent

heat transference conditions due to the close and regular heating surfaces virtually duplicate those of a fire-tube boiler, while a large reserve of water close to steam temperature is always present. The flow of the water counter to that of the gases, with no circulatory flow, and the all-steel construction show a distinct similarity to the flash type. Water is supplied to the boiler by a crank-driven pump, and the water level maintained about half way up the generator by an automatic regulator. If the water level falls below normal the regulator tube will fill with steam, the expansion of which closes a by-pass valve, thereby allowing water from the pump to enter the boiler. As soon as the level reaches normal, the regulator tube fills, through an outside pipe, with water which has not been in circulation in the generator and is therefore comparatively cool. The regulator tube at once contracts, permitting the valve to open and all water to be by-passed back to the supply tank.

We now come to the two most important factors in the perfection of operation of a steam automobile:

1. The ignition system, which permits the driver, seated at the steering wheel, to cause the lighting of the fire in the boiler by the turning of an electric switch.

2. The small combustion chamber in which enough fuel can be consumed to supply the requisite number of heat units to generate and maintain a sufficient steam pressure at all times for driving the engine under whatever road conditions may be required.

Ignition System

In order to start the car, it is necessary to have 4 lb. air pressure on the fuel tank; kerosene is then delivered to the float chamber, which is located alongside of the spray nozzles in the venturi tubes of the blower. This 4-lb. air pressure is obtained first by means of a hand pump on the instrument board, but when the car is running, it is maintained by a small air-pressure pump operated by a cam on the rear-axle shaft. The storage battery is charged by a generator driven through a gear on the axle shaft.

When the switch on the steering column is closed, the current passing through a solenoid starting valve starts the blower motor. The blower, revolving at about 2300 r.p.m., creates a forced draft which by aspiration feeds the kerosene from a float chamber with a proper mixture of air through what are termed the two running nozzles. At the same time that the blower is started by the current passing through the solenoid, the latter magnetizes and raises a small valve which releases air under 4-lb. pressure from a small auxiliary air tank connected with the solenoid valve. This charge of air rushes to a starting nozzle located between the two running nozzles, aspirating kerosene through the starting nozzle with a rich mixture of air.

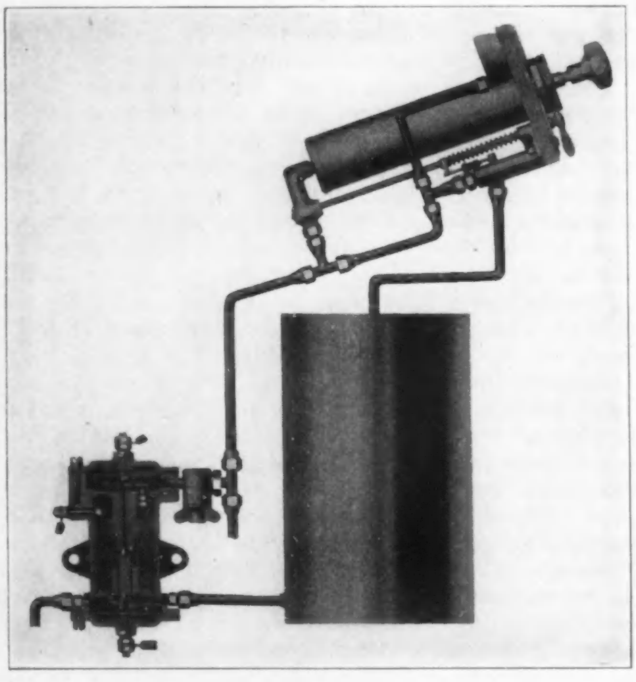


Fig. 5—Solenoid Starting Valve with Auxiliary Air Tank

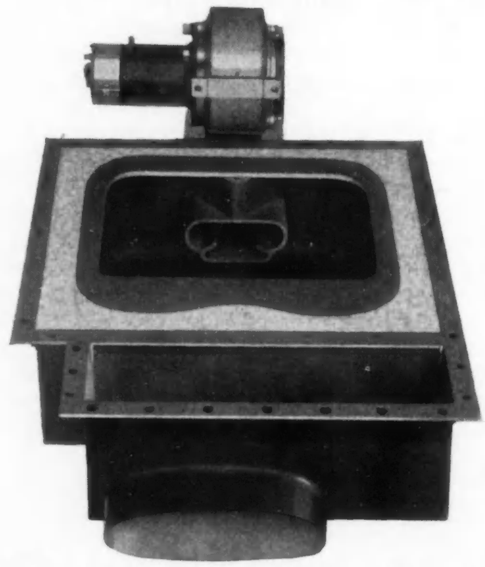


Fig. 6—Combustion Chamber Showing the Venturi Tubes
Starting nozzle in center tube, two running nozzles in outer tubes

Directly in front of the starting nozzle is a spark-plug. At the time the air pressure is released through the solenoid valve, it acts on a diaphragm in the solenoid and makes an electric contact with a spark coil so that simultaneously as air and kerosene are passed through the starting nozzle in an atomized condition, the spark ignites the rich mixture, and this primary flame ignites the lean mixture which is being fed, by the blower, through the running nozzles.

The duration of the primary flame at the starting nozzle and the duration of the spark are governed by the time required to exhaust the air supply in the auxiliary air tank at the solenoid. This occupies the space of about one and one-half seconds.

But the motor is still driving the blower so that the fuel through the running nozzles which has been ignited by the flame of the starting nozzle continues to burn in the combustion chamber.

By a simple automatic regulator, the current to the motor is shut off when the steam pressure has reached 600 lb., and the fire goes out in the combustion chamber. At the same time, the auxiliary air tank is recharged by the solenoid valve dropping to its seat due to the breaking of the current, so that the system is ready to repeat the starting operation which is now being controlled by the steam pressure regulator. When the steam pressure drops to about 550 lb., contact through the solenoid is made again, and the fire is lighted. This requires no attention on the part of the driver and the fire continues to go on and off according to the steam pressure, so long as the switch on the steering column is closed. Driving over ordinarily level roads, the fire will be on about one-third of the time.

Many difficulties presented themselves in working out the details of this method of ignition. At the outset, it was demonstrated that, if a mixture of sprayed kerosene and air was formed in which a sufficient amount of air was injected to insure a complete combustion of the mixture, it could not be ignited by the small flame as produced by an electric spark.

In order that the entire system would respond to the closing of a switch on the steering column it was essential, of course, that ignition of the fuel should take place from an electric spark. It was discovered that a flame of considerable proportion was necessary to ignite the lean, rarefied mixture necessary for complete combustion. After finding that this rarefied mixture fed by the blower through the running nozzles while properly proportioned for combustion could not be ignited by an electric spark, it was necessary to invent some other device for accomplishing the purpose. Experiments then led to the discovery that if a mixture of sprayed kerosene and air was formed in which there was an excess amount of liquid fuel, this rich mixture could be ignited by an electric spark. Therefore, it was arranged to use three spray nozzles. The center, or starting nozzle, was placed between the two running nozzles and slightly ahead of them, so that as the rich mixture in the starting nozzle was ignited the lean mixture being fed past the flame of the starting nozzle at high velocity would become ignited and continue to burn in the combustion chamber.

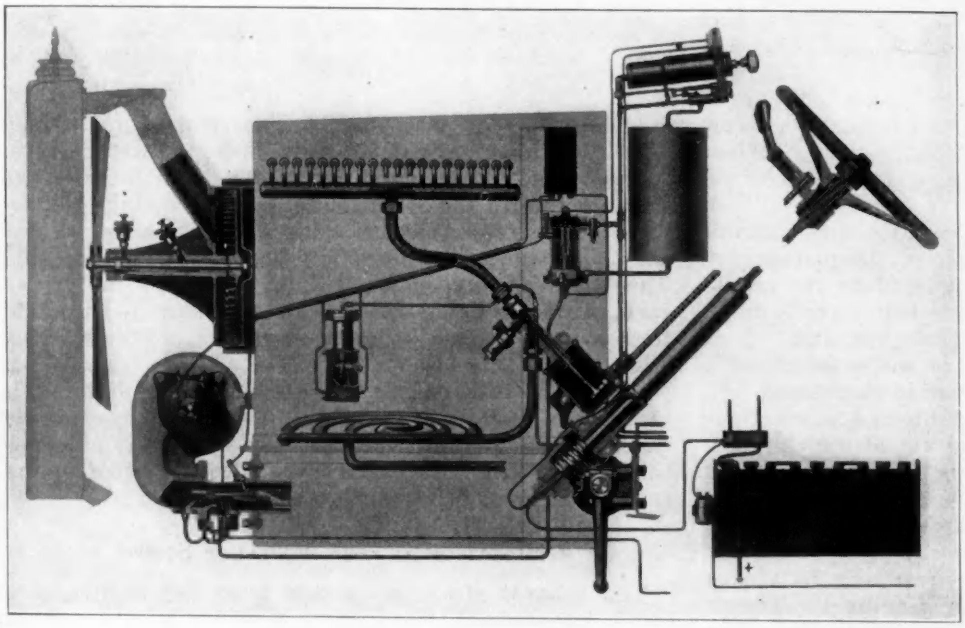


Fig. 7—Automatic Devices on the Live Steam Side of the Boiler
Showing solenoid valve and pressure regulator which lights and shuts off fire as steam pressure varies between 600 and 550 lb.

Many problems presented themselves in bringing about the highly desirable conditions mentioned in the foregoing description.

The most important problem was to be able to avoid the vaporizing or gasifying of the liquid fuel used in the combustion chamber for the generation of steam. In all former attempts to burn liquid fuel, the vaporizing process was employed; in this a gas flame was produced which could readily and easily be confined in the limited space available for the fire-box of an automobile boiler. To convert kerosene fuel into a gas necessitated the use of pilot burners or preheating devices that required considerable time to acquire a sufficient temperature before the gas flame was available. With devices of this nature, it has not been possible to construct a steam car in which the operator can sit at the steering wheel, close a switch and move off with that degree of promptness that has been made possible in the most highly developed gasoline cars.

In the present-day steam car we can enjoy greater conveniences by the electric control of steam; and, in addition, we have the many advantages which only the smooth, flexible power of steam can give us.

The space available for a combustion chamber, or fire-box, for a steam boiler is limited in a steam-driven automobile—so limited, in fact, that without changing the conventional lines of the modern automobile hoods, a fire-box 20 in. square and 8 in. deep was as large as could be employed.

It is well known that if the flames from burning fuel be permitted in contact with the flues or water tubes of a boiler, the products of combustion will readily form smoke and soot, and that the tubes will soon become so heavily coated as to reduce materially the evaporating capacity of the boiler.

When oxygen in the form of air is supplied with the atomized liquid fuel, sufficient not only to support complete combustion, but also to produce a temperature sufficiently high to insure ample steam pressure under all possible demands, an immense body of flame results.

The main problem, therefore, was to construct a firebox of such shape that the sprayed fuel and air could be injected into it and that the flaming combustible could absolutely be retained within the limits of the combustion chamber and not come in direct contact with the water tubes of the boiler.

The method of burning the fuel consists in projecting a stream of sprayed kerosene and air in sufficient proportion to support complete combustion and with such force as to compel the stream to remain in a horizontal plane. The stream is doubled upon itself in a horizontal plane to confine it in parallel planes until combustion is complete.

This has been accomplished by arranging the shape of the combustion chamber, so that the fire is almost completely confined in the fire-box and does not come in direct contact with the boiler tubes.

Construction of the Engine

The engine is exceedingly simple and contains but eleven moving units. The dimensions of all the working parts are ample to insure uninterrupted service under maximum conditions of load. The engine is 5-in. bore, 4-in. stroke, of the two-cylinder, single expansion, double action type. The unaflow principle is employed in order to provide the high expansion desirable, with a noiseless valve gear and only one valve per cylinder. The valve takes care of the steam inlet, while the exhaust passes out through ports uncovered by the piston at the end of the stroke. It is thus possible to secure cut-off at 3/16 of

the stroke. This cut-off is used for all ordinary running, and operates with perfect accuracy on either stroke of the piston. For starting or heavy pulling a cut-off is used at three-fourths of the stroke.

Since the thermal conditions in the unaflow cylinder are practically ideal, it is unnecessary to use superheated steam, but it is desirable because it reduces the weight which must be condensed. The slide valves are on top of the cylinder, and are each made in two pieces so that in slow running they can be lifted whenever the compression exceeds the steam-chest pressure. This makes the engine run smoothly at all speeds, and also allows a high compression at higher speeds and steam-chest pressures.

The valves are actuated by a specially designed valve gear, which dispenses with the need for eccentrics, thus making a one-piece crankshaft possible. This gear gives an excellent steam distribution, and also reverses the engine without additional devices. It is a simplified form of the Joy valve gear, from which the correcting and anchor links have been eliminated. The rocker guide is straight instead of curved.

The piston rod passes through a specially designed gland, which is made in such a manner that no steam can blow by it. On account of the long bearing surface there is practically no wear, and repacking is rarely required.

The crankcase is an aluminum casting, and contains the moving parts of the engine, except the pistons and valves. The differential is also contained in the crankcase, and the taper-tubes of the axle bolt directly to it, thus making the engine and rear axle one unit.

The forward end of the engine is suspended from a cross-member of the frame by a flexible steel strap.

The crankshaft, differential and big-end connecting-rod bearings are annular roller and are of such proportions that no wear can occur during the natural life of the car. All of the other bearings, such as the wrist-pin and valve-gear bearings, are hardened steel, running in hardened steel bushings.

The power is transmitted to the rear axle by means of two large spur gears, a 42-tooth gear on the engine crankshaft and a 54-tooth gear on the differential. The engine has more power than is needed to spin the wheels on dry pavement, while the car is held stationary.

Method of Lubrication

Gas engine cylinder oil is supplied to the crankcase of the engine. This is splashed by the crankshaft and main driving gears and lubricates the working parts of the engine. By means of a small oil-feed pump, the oil from the crankcase is also delivered to the steam chest of the engine, lubricating the valve seats, valve stems and cylinders. This lubricator is set to feed one gallon for each 5000 miles.

Passing through with the exhaust steam from the engine a small quantity of oil continuously finds its way to the water supply tank and is fed with the water into the boiler. The oil is accordingly regularly pumped into the boiler along with the water, and far from having a deleterious effect, really performs its most valuable functions in that part of the powerplant. This oil is very thin at 490 deg. fahr., the approximate steam temperature at 600 lb. pressure, and the coating of oil, which forms over the entire inner surface of the boiler, is consequently so thin as to have a negligible effect upon the heat-transference conditions.

As scale does not adhere to a surface coated with oil, the interior of the boiler remains entirely free from incrustations of scale matter, and is likewise thoroughly protected from corrosion. The second function of the oil is to coat each particle of scale-forming material as it is thrown out of solution, thus preventing one particle from sticking to another in such a way as to form a body of sufficient size to clog some restricted passage. No

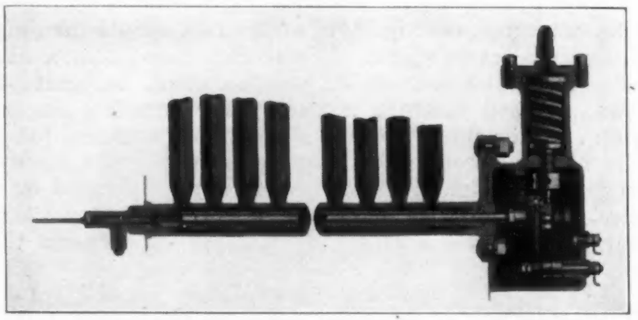


Fig. 8—Sectional View of Steam Pressure Regulator and Low Water Cutout

large amount of scale-forming material is introduced into the system since but little make-up water is required. The violent ebullition and constant flow of the medium toward the steam outlet causes the minute particles of scale to be carried along with the steam, so that the boiler and radiator are both kept free from deposits. The scale-forming material finally reaches the water tank, where it either remains or continues to circulate through the system without any apparent deleterious effect.

I have carefully examined the boiler and radiator of a car driven over forty thousand miles, and they were as clean or cleaner than when the car was built. I do not believe that there could be a more adequate proof of the entire effectiveness of the system.

Utilization of the Exhaust Steam

The exhaust steam is carried from the engine to a small, low-pressure steam turbine which is mounted on the front of the boiler casing. The condenser fan is on the shaft of the turbine. By the use of the turbine, a greatly increased efficiency in condensation is effected, as when the engine is working the hardest on grades or heavy roads, the turbine will be driven at an increased speed, so that the fan will draw more air through the condenser at the time it is most needed, regardless of the car speed.

Advantages of Steam Power

Let us now briefly sum up the advantages of steam power for driving automobiles, as compared with the internal combustion engine. These are:

1. Torque range of 100 per cent with a maximum torque available at zero speed; change-gear mechanisms and clutch therefore unnecessary.

2. Mean effective pressure (and equivalent drawbar pull) always under control of the operator; variable by throttle and cut-off from zero to maximum, a maximum limited only by the tractive capacity of the rear wheels.

3. Utmost mechanical simplicity with not over twenty-four moving units in the entire car and only eleven in the engine.

4. Low manufacturing cost, owing to simplicity of construction and lack of "fussy" work in production.

5. Entire absence of lubrication troubles; no con-

tamination of crankcase oil by kerosene, gasoline, water, road dust or carbon.

6. Low fuel cost per mile.

Observations of Performance in Actual Practice

The following tests were made without a superheating coil. It is my opinion that on our present boilers with superheaters, we are getting at least 20 per cent greater evaporation without priming than was possible on the earlier boilers with which these data were taken.

Total tube surface in boiler, sq. ft	143
Total tube surface in economizer, sq. ft	34
Total tube surface in boiler and economizer, sq. ft	177
Total water surface in boiler, sq. ft	118
Total water surface in economizer, sq. ft	25.9
Total water surface in boiler and economizer, sq. ft	143.9
Total capacity of boiler, cu. ft	1.425
Total capacity of economizer, cu. ft	0.333
Total capacity of boiler and economizer, cu. ft	1.758
Total capacity of boiler and economizer, gal	10.8
Total capacity of boiler and economizer, with 11 in. water level, gal.	9.
Total weight of boiler and economizer sections, lb	450
Actual evaporation, lb. per hr	630
Equivalent evaporation, lb. per hr	765
Equivalent evaporation, per lb. of kerosene, lb	18.05
Equivalent evaporation, per sq. ft. of boiler surface, lb	7.38
Equivalent evaporation, per sq. ft. boiler and economizer, lb	5.20
Fuel consumption, lb. per min	0.687
Temperature of steam at boiler, deg. fahr	515
Superheat, deg. fahr	25
Pressure, lb. gage	600
Heating surface including economizer, sq. ft	146.7
Overall efficiency, per cent	90
Temperature feed water, deg. fahr	62
Boiler horsepower	22.25
Temperature flue gas, deg. fahr	410

Water Consumption at 60 m.p.h.

Volume of cylinder = 19.6 × 4 = 78.4 cu. in.
Volume at 3/16 cut-off. 3/16 × 78.4 = 14.65 cu. in.
Volume per revolution for two cylinders 58.6 cu. in.
Volume at 60 m.p.h. or 740 r.p.m. = 740 × 58.6 = 43,400 cu. in. = 25.2 cu. ft.
Steam chest pressure, 250 lb.
Weight 1 cu. ft. steam @ 250 lb. pressure, 0.57 lb.
25.2 × 0.57 = 14.3 lb. water.

Engine Data

Bore, in.	5
Stroke, in.	4
Unaflow, double-acting, two-cylinder, Doble valve gear cut-off	3/16 ; ⅜ ; ⅝
Gear ratio to rear axle	42 to 54

General Data

Wheels, in.	35
Tires, in.	5
Wheels, r.p.m.	576
Engine, r.p.m.	740
Ratio dynamo speed to rear axle speed	9.43 to 1
Ratio dynamo speed to engine speed	7.33 to 1
R.p.m. at 30 m.p.h.—Wheels	288
R.p.m. at 30 m.p.h.—Engine	370
R.p.m. at 30 m.p.h.—Dynamo	2,712

Advantages from Manufacturing Standpoint

The following manufacturing advantages of the steam car are greatly in its favor:

1. The much smaller amount of material required.
2. The small number and simplicity of machining operations.
3. Minimum investment in factory and equipment in proportion to quantity produced.
4. Comparatively small number of parts entering into the construction of the powerplant.
5. Comparatively small finished stock necessary to carry for service and repairs.
6. Ability to turn capital more often for a given output of complete units.
7. Minimum of accounting and inspection costs due to comparatively small number and simplicity of parts.
8. Minimum cost of individual tests of component parts and the final test, inspection and adjustment of the completed car.

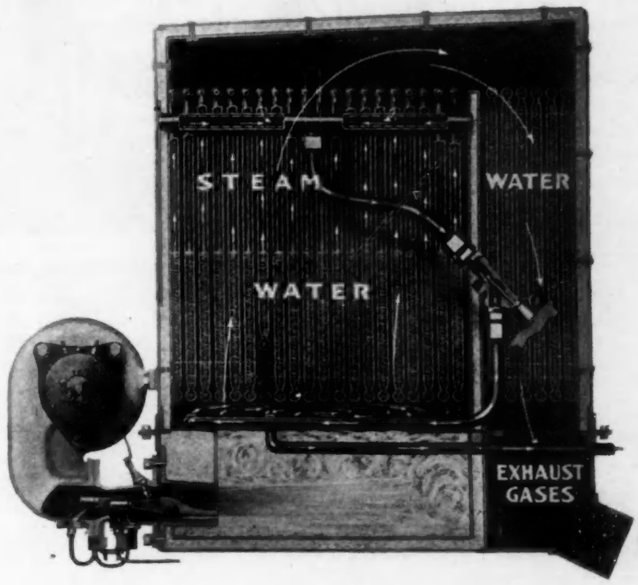


Fig. 9—Cross-Sectional View of Doble Boiler
Steam side showing economizer sections filled with water and generating sections filled to normal water level

9. All of the foregoing conditions mean a great reduction in labor which in the present condition of shortage is of paramount importance.

Steam Car in Relation to Fuel Problems

A report of the Bureau of Mines furnishes some figures on the fuel question which are most interesting in view of the fact that the steam car uses kerosene for fuel.

The total production of gasoline in this country for the first three-quarters of 1917 was 1,962,205,420 gal. Estimating the fourth quarter at the same rate would give us 2,616,273,893 gal. for the year 1917 against 2,058,322,838 gal. in 1916.

The production of kerosene for the first nine months of 1917 was roughly 1,226,000,000, or, for the entire year, 1,834,000,000 gal. The total yield for kerosene in 1916 was 1,455,500,000 gal. From these figures it will be seen that there was an increase in gasoline production of 557,951,055 gal., and an increase of kerosene production of 378,500,000 gal. Stocks on hand at refineries were as follows:

	June 30	July 31	Aug. 31	Sept. 30
Gasoline (gal.)	364,976,344	345,199,195	298,548,699	287,758,562
Kerosene (gal.)	438,967,247	516,752,342	511,639,188	508,461,071

This shows that the surplus stock of gasoline constantly decreased for the months of June, July, August and September, while the surplus stock of kerosene increased.

Therefore, from the standpoint of conserving the gasoline supply as a war time measure, the steam car, using kerosene, is an important factor.

The automobile consumption of gasoline in 1918, as set forth by the sales manager of one of the big eastern oil companies, will be 2,250,000,000 gal., while the total demand for the year will be 3,155,000,000 gallons.

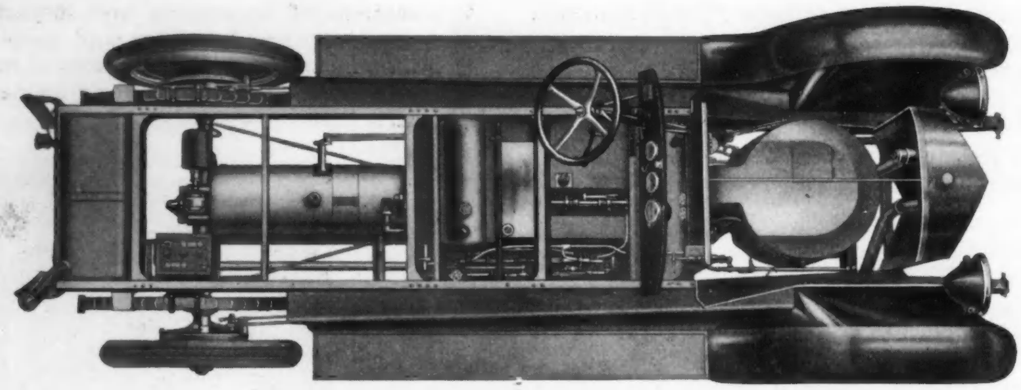


Fig. 1—Chassis of the Stanley Steam Automobile Showing Positions of Powerplant Units

The Case for the Steam Car

By JOHN STURGESS* (*Non-Member*)

METROPOLITAN SECTION PAPER *Illustrated with* PHOTOGRAPHS AND CHART

WE believe we can best serve the members of the Society by answering three questions: why we build steam cars, why we build our particular type of car, and by what process we have eliminated other types. While *our* aims and activities have been completely lost sight of by gas-car builders (we being a minute minority), we have naturally been fully cognizant of *their* aims and activities, as was unavoidable from their prominent position.

WHY WE BUILD STEAM CARS

The first answer, then, to the question, why do we build steam cars, is, because we *have* been cognizant of the aims and progress of gas-car builders, year by year since the industry began. And while being foremost to applaud their progress, and first to recognize the popularity of the gasoline automobile, we have each year become more and more confirmed in our determination to keep on building steam cars. Why? Because we have seen in the public's demands, and in efforts to meet those demands, an unmistakable longing for a performance which we, knowing internal-explosive cars as well as steam cars, believe steam *alone* can give—an ideal performance, to reach which steam is not only the shortest, but, indeed, the only route.

To conceive the performance which public and manufacturers alike are longing for, it is necessary, we believe, to abandon the standard of smoothness, flexibility, range of power, responsiveness, sense of security and command, which it is now habitual to accept, and to picture a standard set upon a far higher plane; and furthermore to secure this new standard with a powerplant far less complicated than is now tolerated, and to insure complete control and mastery by the movement of a single lever.

We believe any manufacturer will state that he desires to sell the public what it wants—and that he will agree that what the public wants is a car with a soft, smooth, gliding motion, without noise or vibration at any speeds; without clutch or gearshift; without overheating in the summer or overcooling in the winter; with the smallest possible number of cylinders, moving parts and lubrication difficulties; with no possibility of stalling; with stored power built up in advance and replenished as fast as used, ready for instant application to the driving wheels; with ratio of car speed to engine speed always constant; with the ability to apply the maximum driving effort under the most adverse conditions; with one-finger control; and with kerosene fuel.

We do not underestimate the high standard already attained by gas cars in many of these directions, and it may be said that the public is satisfied with what it now has and cannot demand a standard beyond its conceptions. But if a higher standard is attainable, and the public becomes enlightened, what then? The demand will inevitably follow. It is our conviction that this will come to pass.

We believe all will agree that the true measure of any car's performance may be made under the following headings:

Range of power.
Smoothness of propulsion.
Ease of control.
And its desirability is further to be measured by its
Durability.
Reliability.
Reasonable economy of operation.

Our contention that cars having steam powerplants are inherently superior to those having internal-explosive powerplants rests on the following statements:

Range of Power

The general terms flexibility, reserve power, hill-climbing power, acceleration and speed, are the manifestations of the first quality, range of power. We use this term in a wider sense than range of horsepower, for the question of reserve power is involved. Horsepower is measured by three factors. It is force exerted over a given distance in a given time. Of these three factors, force only is what the motorist has in mind when he speaks

*Stanley Motor Carriage Company.

of reserve power—the driving force. This is the only factor which he can control. When he applies this by opening the throttle, speed, and consequently horsepower, may or may not result.

Range of power, therefore, becomes range in the magnitude of force applicable to the driving wheels. Reserve power becomes the difference between the driving force utilized at any moment and that which may be utilized at such moment. Both are the direct result of range of effective cylinder pressures, with given gear ratio and piston displacement. One of the prime essentials of comfortable motoring is the sense of security from the consciousness of reserve power that may be instantly applied, so we will compare steam and gas cars in this respect.

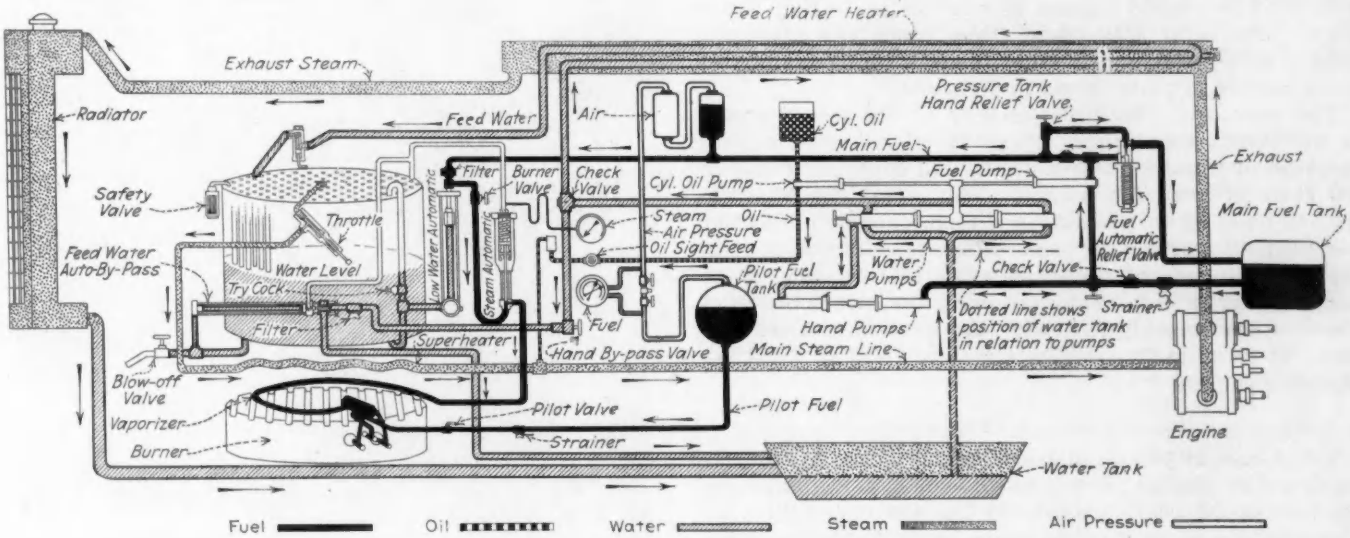


FIG. 2—DIAGRAMMATIC PIPING LAYOUT OF THE STANLEY STEAM AUTOMOBILE

Reserve Power

The maximum mean effective cylinder pressure in the gas car averages about 100 lb. The steam car has in reserve cylinder pressure well up to 500 lb. Applying gear ratios and piston displacements to both types to obtain net driving effort or force, we will compare a $3\frac{1}{8}$ by $5\frac{1}{8}$-in. eight-cylinder and a 3 by 5-in. twelve-cylinder gas car with the standard 4 by 5-in. two-cylinder steam car. Gear ratios will be about $4\frac{1}{2}$ to 1 in the gas cars and $1\frac{1}{2}$ to 1 in the steam car.

The eight-cylinder engine will have a piston displacement (omitting non-working strokes) of 77 cu. in. per foot of car travel and the twelve-cylinder will have one of 104 cu. in. The steam car will have one of 41.4 cu. in. Multiplying these values by the maximum effective cylinder pressure, we obtain the following indices of driving force:

Gas car, eight-cylinder ($3\frac{1}{8}$ x $5\frac{1}{8}$).....	7,700
Gas car, twelve-cylinder (3 x 5).........	10,400
Steam car, two-cylinder (4 x 5).........	20,700

From this it will be seen that the range of driving force, and consequently the reserve power in the steam car is greatly in excess of either of the above typical gas cars, which accounts for the remarkable acceleration and hill-climbing powers of the steamer.

The above calculations with gas cars are based on direct drive (high gear) because the accepted standard of their performance is what they will do on high gear. They are advertised, sold, and judged in service upon this basis.

Of course, the gas-car owner can shift to the low gear for greater power at reduced speed. But every time he does this he concedes the claim that the steamer possesses superiority in not doing it. Moreover, he himself will do it only as an emergency measure; he admits, with mortification, that he is ever forced to do it; so any effort on his part to derive controversial advantage from his ability to do it is distinctly insincere.

The gearshift has well been called a makeshift. It is a most unsatisfactory solution of the problem. Every motorist is demanding a better one, and every manufacturer is trying to find it. The fact that no gearshift is needed with a steam car is one of the strongest reasons why we build such cars.

It is not claimed that the steam car can maintain the above high tractive effort indefinitely at high speed. Such would not be necessary under any road condition ever likely to be encountered. Its temporary availability is all that is desirable. Even with 400 lb. mean effective pressure, at 30 m.p.h., such tractive effort would amount to 80 hp.; at 50 m.p.h., it would equal 130 hp. This great amount of power is available for as long a period as road conditions would usually permit its use.

It is probably true that many stock gas cars, including the typical cars cited, could maintain a higher rate of speed on an ideal track, say on Sheepshead Bay Speedway. But what proportion of the power the gas car develops on the track is available on the road? What is the value to the motorist of a track performance which cannot be duplicated on the road he is going to use?

It is not that steam cars cannot be built to meet track conditions. But in order to maintain a high average road speed, with acceleration inconceivable to the gas-car driver, the steam car does not have to be equipped with a powerplant capable of producing an amount of power that can rarely, if ever, be used continuously. There is small consolation to the driver who has averaged only 40 m.p.h. on good roads to say that on Sheepshead Bay Speedway his car would average 70 or 80 miles.

There is a certain subtlety to this that can best be realized when a car known to be capable of say 75 m.p.h., in ordinary road going, at 40 m.p.h., is suddenly passed by a steam car which has been trailing for

miles, the steam car suddenly shooting ahead, within the space of a few rods, at the rate of 60 m.p.h. or more. From our experience we know that no car can show such acceleration unless it is capable of 90 m.p.h. at least. This is what misleads many people to think that the Stanley is the fastest car in the world. It is not, by any means, if we mean indefinitely maintained speed. It does not have to be to meet the conditions of motoring that the driver is faced with every day and wants most to overcome.

In the old days, before condensers were used, when steam cars were limited to a water mileage of 30 to 40 miles, a Vermont farmer once said he would not buy one because he could not cross the Great American Desert with it if he should happen to want to go to San Francisco. The reply was made, "Nor could you cross the Sahara with a horse. But that is not a sound reason for using camels to plow farms in Vermont."

The source of this great energy is the stored power in the boiler, represented by 60 lb. of water at a temperature of nearly 500 deg. fahr., and containing 1,500,000 ft-lb. of available energy. This great potential energy is built up in advance in a form capable of instant use, without waiting for combustion to take place. It is one of the secrets of the steam car's performance. Such stored power is obtainable only with the steam boiler of liberal water capacity, or with the electric storage battery. It is quite impossible with any form of internal-explosive engine.

Smoothness of Propulsion

This range of power, and its method of application, by gearing the engine direct to the rear axle, which in practice would be impossible in the gas car, results in a smoothness of propulsion which is particularly apparent at moderate speeds, especially during heavy going. It arises from the fact that two double-acting steam cylinders produce a perfectly uniform continuous turning moment on the crankshaft.

At high car speeds this smoothness is also gratifying. The engine speed is always in identical ratio with the car speed, and at 60 m.p.h. the engine is running at but 864 r.p.m., with 3456 piston reversals a minute, compared with say 2500 r.p.m. and 40,000 piston reversals a minute in an eight-cylinder gas car.

Ease of Control

In steam cars, control is far more completely centered in the single-throttle lever than gas-car control is centered in the gasoline throttle. It is even far more completely centered than in the gas throttle *plus* the gearshift; and in the steam car the gearshift is completely eliminated, and no substitute is needed. The single throttle-lever suffices to start the car from rest and to control the power from zero to 500 per cent above rating. A few inches' movement of one lever covers the entire range. A still further increase in power is obtained by releasing a pedal, but this is only needed on the rarest occasions. Reverse is effected merely by pressing the above-mentioned pedal forward, if desired, while the car is still running forward.

Turning to the mental aspect, or degree of driver's attention, the only thing the steam driver is cognizant of is the speed of the car. Car speed and steering are all he has to think of. The mechanism of the car can be completely dismissed from his mind.

The gas-car driver, on the other hand, has to give a certain degree of attention to engine speed, to the extent of almost complete absorption when starting, or in heavy traffic. One condition governs car speed, other conditions govern engine speed. The driver must maintain a mental picture of both so as to be alert to adjust their relationship, and this adjustment involves action by his two feet and one hand or one foot and two hands, and he must do it *at once* or he is too late.

Ease of Starting

It is commonly supposed that in starting the steam car is at a great disadvantage, requiring much preparation and considerable time. This is a very erroneous impression. A true comparison of the preparedness for instant motion of steam and gas cars is to the advantage

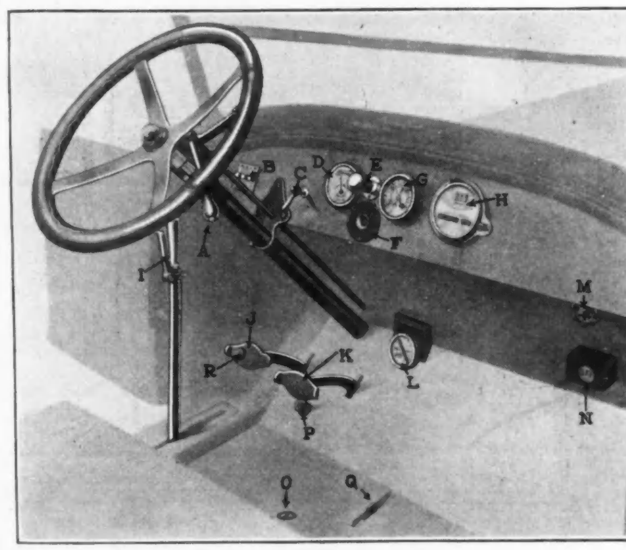


FIG. 3—INSTRUMENT BOARD AND CONTROL DEVICES

A—Throttle	L—Water level indicator
C—Main burner control	M—Hand bypass valve
D—Steam gage	N—Sight electric indicator
G—Fuel pressure gage	O—Water tank gage
J—Reverse pedal	P—Horn button
K—Foot brake	Q—Hand pump lever stub

of the steamer. For such comparison will embrace all starts occurring all day and every day, not simply the individual case when the steam car is cold, this constituting not 5 per cent of all starts made. It will then be apparent that the normal condition of the steam car is one of readiness for instant start, even before the driver has taken his seat, a single movement of the throttle lever being all that is needed. This is true for probably 95 per cent of all starts made, arising from the simple fact that steam is up *all* such time, and is to be contrasted with the well-known sequence of operations in starting a gas car, involving time, close attention, dexterity, and not infrequently unpleasant noise.

Eloquent of the ease of making the numerous daily starts with a steam car is the complete unconcern of the motorist at making any number of stops, again in contrast with the frequently dangerous inclination of the gas motorist to take chances rather than to do so.

Even in the initial daily start, after the car has been standing for a considerable time, the facility of starting is hardly less, for the pilot has maintained a good head of steam, and it is necessary to open up the main burner only a moment before starting.

It is only when steaming up from cold, which need not occur once in several weeks if the pilot is kept burning (as it usually is) that the steam car may be behind the gas car in starting. But if as in most cases the time at which it is desired to start can be anticipated by 5 to 10 minutes, and the burner started accordingly, there need

be no delay. It is true it used to be a somewhat irksome matter to set the burner in operation, just as it used to be even more irksome to crank the gas car by hand; but today it is only necessary to press a button to heat and ignite the pilot, and then open the main burner valve. Steam is available a few minutes later.

Cold-Weather Starting

The foregoing comparison of starting facility would not be complete if reference were not made to winter conditions. The zero morning in the cold garage causes no apprehension to the steam motorist. There is no fear that he may have a ten-minute fight with his engine, nor is there any consequent leaking of unwelcome gasoline into a crankcase. The long, frigid waits at the curb are perhaps more dreaded by the gas-car motorist than anything else. Only short runs are made in cold weather, with long stops. Stored heat is the best weapon to fight this difficulty. That is why the gas motorist is more watchful to have his radiator full in the winter than in the summer. In the steam car there is a greater volume of stored heat, and it is better distributed than in any other car. The steam motorist does not have to enrobe his radiator at every stop, for it presents no thin sheet of water to the air. It is empty the minute the car stops.

The steam car does not freeze for the same reason that the building provided with a hot-water heating system does not freeze; but whereas the building has chilling windows, all susceptible parts of the car are heavily clothed with insulation. Consequently the small pilot, always burning, maintains the heat. If there is objection to long-continued burning of the pilot, a small city gas jet with hose connection to the burner suffices, and costs little. Finally, the water in the boiler can be drained with little effort, or even be permitted to freeze solid with but slight danger, and that only to small parts.

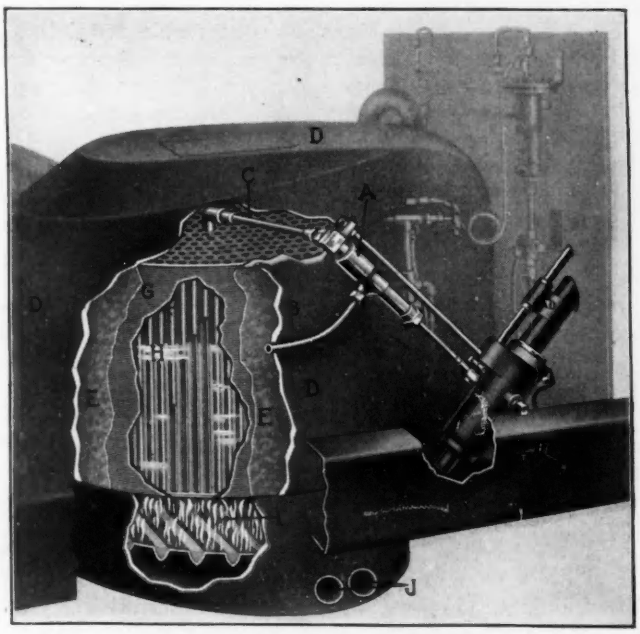


FIG. 4—SECTIONAL VIEW OF BOILER

A—Throttle
B—Outlet to superheater
C—Steam outlet from boiler
D—Asbestos covering
E—Galvanized iron covering
F—Boiler tubes
G—Piano wire
H—Water level
I—Main burner flame
J—Main burner mixing tubes

Durability of the Steam Car

A further motive for building steam cars is that deterioration by age and use of the steam powerplant does not appreciably affect the performance of the car. In other words, it is more enduring. This is due to the low-speed engine, completely encased, of few moving parts; to absence of dust taken into the cylinders (characteristic of all internal-explosive engines); to simplicity of the direct connection to driving wheels, without the complicated transmitting devices of the gas-car clutch, jointed shafts, and gear boxes; and, in fine, the less sensitive steam-power cycle.

Life of Steam Boiler

Durability of the boiler is not dependent on wear in the ordinary sense, for it has no moving parts. At the same time, deterioration naturally occurs. The normal life of a boiler is from four to five years. Replacement does not, therefore, result in an appreciable annual repair charge, especially in view of the low cost of other repairs.

Examples of Reliability

In respect to accidental derangements, consequences of such, and readiness of effecting correction, the steam car again is superior. Local failures may lame the car, but rarely, if ever, halt it. It can always get home, even if it has to limp a bit. Steam cars have been driven home comfortably on one cylinder, the other having a broken connecting-rod, without stopping to make repairs. Engine parts have worn half an inch (through long-neglected lubrication) and the driver hardly knew it. Boilers may start leaking, but the car can still be run hundreds of miles before the leak is likely to become serious.

Automatic features may conceivably fail, but the driver can still operate under hand control. The fuel tank may become unexpectedly empty, but there is no dying gasp without notice. The steam car can run several miles without fuel by drawing on the stored power, and kerosene (the fuel) can usually be obtained within that distance. The radiator may leak faster than it can be filled, but the steam car cares nothing for that; it enjoys an empty radiator. The battery may give out, but that does not affect the powerplant. The feed pumps may conceivably fail, but the supplementary hand pump may be used in such emergency.

SUMMARY OF ADVANTAGES

Having concluded to build steam cars for the foregoing reasons, we will next state why the essential features of our burner, boiler and engine have been adopted.

Burner.—We use the vaporizer system, the fuel being vaporized by heat and burned on the bunsen-burner principle. We do so because we consider it outclasses other systems in respect to weight, space, stability, security, automatic regulation, the conservation of stored power, simplicity of apparatus and starting facility.

Minimum weight results from the burner comprising only a vaporizer tube with nozzles, mixing tubes and burner chamber, the total weight of these parts being 65 pounds.

Minimum space results from the short flame length and intensity of combustion.

Stability results from the fixed conditions, owing to absence of all moving parts.

Security results from the closed combustion chamber and small amount of fuel contained within the burner at any one time.

Automatic regulation is facilitated by the ease of controlling the rate of combustion.

With regard to the last claim, starting facility, we refer to facility of starting the burner, not the car, for, as already explained, the burner does not have to be

started once in a hundred times that the car is started, owing to the steam pressure continuously maintained by the pilot. But on those few occasions the burner is started by simply pressing an electric button.

Boiler.—We have adopted the fire-tube drum type of boiler, because we believe it satisfies the requirements of stored power, ample steaming capacity, large disengaging surface, dry steam qualities, positive control, small size and weight, endurance, constructional facility, and absolute safety.

Its great stored power results from its large water content, maintained at full temperature. It contains 60 lb., which represents 1,500,000 ft-lb. of available energy.

Its ample steaming capacity results from its 104 sq. ft. of heating surface, afforded by 750 half-inch tubes.

Its large disengaging surface results from its large diameter and shallow depth—2 sq. ft. to disengage the steam generated in 8-in. depth.

Its dry steam qualities result from this disengaging surface, the liberal steam space, the high pressure, and the drying effect of the fire tubes within the steam space.

Positive control results from the definite water level and large water content.

Its small size results from the absence of idle space. It is but 23 in. diameter and 14 in. deep.

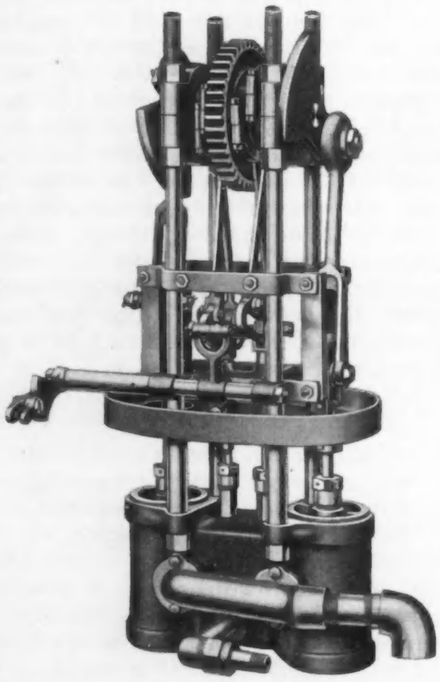


FIG. 5—TWO-CYLINDER STANLEY STEAM ENGINE

Endurance results from its simplicity of design, substantial proportions, and low intensity of action.

Constructional facility results from standardized and familiar manufacturing processes employed.

Absolute safety results from the fact that the boiler simply cannot explode, or even rupture, with any dangerous result. Long before the ultimate strength of the wire-wound shell is approached the small tubes collapse in such manner that the escape of steam is shielded, and sufficiently gradual to obviate all danger.

Engine.—We use a two-cylinder, double-acting, slide-valve engine, 4 by 5 in., with Stephenson link valve motion, straight crankshaft, carried in large roller bearings, overhung single-web cranks at 90 deg., and roller bearings on crankpins. The engine is permanently geared to the rear axle, without clutch or transmission, the gears being plain spurs of large diameter set in the center of the crankshaft, between the bearings. The gear ratio is such that there are 1½ turns of the engine to one turn of the driving wheels.

The prevailing pressure is between 100 and 200 lb. per sq. in., but may easily be run up to double this, or even to full boiler pressure for rare emergencies. Normal cut-off is at ⅜ stroke, but may be changed at will to ⅝ stroke. The range of tractive effort resulting from this, notwithstanding the low gear ratio and two cylinders, is, as already stated, double that of the average high-power gas car.

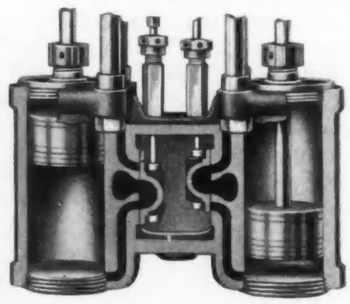


FIG. 6—SECTION VIEW OF CYLINDERS AND STEAM CHEST

Such an engine combines all conceivable requisites of smoothness, great power range, uniform turning effort, few moving parts, light weight, long life, economic operation and rugged simplicity.

The engine weighs 265 lb. A stock engine under test-block run has frequently operated with a steam consumption of 16 to 17 lb. per hp-hr., a remarkable result from so small an engine.

ELIMINATION OF OTHER DESIGNS

Other designs have been eliminated by rigidly keeping in view the basic requirements enumerated above, and checking deductions by repeated tests on all conceivable alternative designs.

With burners, the atomization system using air, steam, and mechanical means for atomizing the fuel have been extensively experimented upon, but according to our experience have not satisfied all the requirements of automobile needs so well as has the vaporizer system. An intense combustion is obtainable, but in respect to weight, size, simplicity and ease of control, stability and maintenance of stored power when the car is standing, as well as in numerous practical difficulties, the atomization system has not, so far, matched up to the vaporizer system such as we employ. It requires either a steam jet or considerable additional apparatus, such as power-driven blowers or atomizers. The burner must be repeatedly extinguished and re-lighted in the process of regulating steam pressure, and while maintaining this pressure when the car is standing; this involves starting up the power-driven blower and electrically igniting the gases, obviously an undesirable condition while the car is unattended. This is not to be compared, in point of safety, to the maintenance of a small continuously burning pilot, and a graded combustion of the main burner.

The flash type boiler has not been thought worthy of serious consideration, its sole claims being that it will quickly steam up and that its thermal efficiency is good.

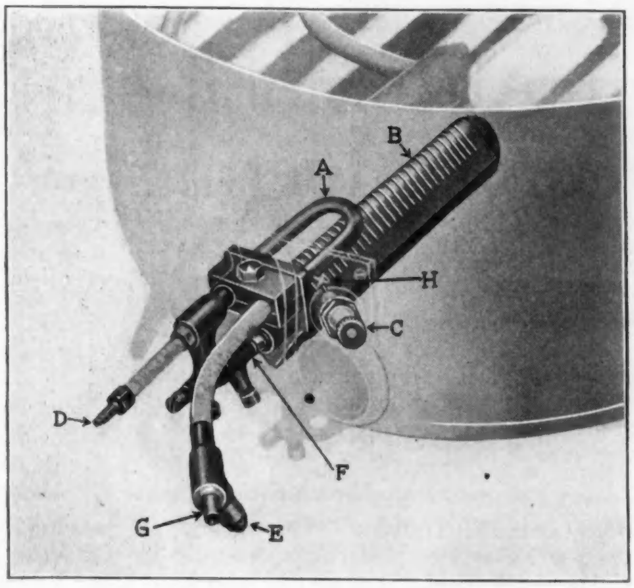


FIG. 7—PILOT CASTING ASSEMBLY

A—Vaporizing tube
B—Pilot casting
C—Spark-plug
D—Return connection to switch
E—Fuel inlet
F—Pilot nozzle
G—Connection from battery
H—Spark gap

It completely lacks the prime essential of stored power, and its control is complicated and highly uncertain, in that both temperature and pressure have to be regulated.

The water-tube type may be regarded as a compromise between the flash and drum types. Its principal claim is that steam can be raised quickly, owing to small water content, but this obviously sacrifices the paramount advantage of stored power and overload ability, which is directly proportional to water content. Power quickly built up is quickly spent. Furthermore the pilot and vaporizer system of combustion maintains steam pressure at practically all times, as already explained when speaking of starting facility, and the occasions when quick steam-raising would be beneficial are so few as to render this nominal benefit of no practical advantage. In 99 out of 100 cases the car with the drum-type boiler with pilot would be away down the road before the car with the water-tube boiler without pilot would have gotten up steam, although in the one case in a hundred the latter might be a few moments ahead.

The water-tube type is more difficult to control as regards water-level, in fact so far it has not been satistorily controlled in this respect at all. Furthermore, the control problem involves more complication, which is undesirable. Water-level and circulation are quite uncertain owing to the weakness of parallel circulation and tendency of the circulation to reverse, resulting in the so-called "geyser effect" and danger of burning the tubes.

A refractory lining is necessary in the casing of the water-tube boiler, which, while a minor objection, still constitutes an additional problem, especially when the dimensions and weight are reduced to the extent they must be to suit automobile needs, where weight and space are at a premium.

As the engine is a relatively minor problem in steam cars—owing to steam engine practice being so highly standardized—difference of type or details of construction are of not such pronounced moment as the major problems of burner and boiler. Another company (now among the gas-car manufacturers) for a few years used a compound engine. The unaflow type has been proposed and much discussed recently. We conducted tests on a unaflow engine a year ago and failed to discover any superior steam economy. We did encounter many minor disadvantages of this type when applied to automobiles, among which were uncertainty at times as to whether the car would run forward or backward on starting, and the possibility that it would not start at all. Furthermore, its high compression was a disadvantage and its weight and size exceeded that of the contraflow type.

These difficulties could be overcome in considerable measure, but so doing would modify the unaflow type to the point that its characteristic feature would be largely lost, and there would be added complications in construction.

The use of high superheat, moreover, largely minimizes the benefit of the unaflow cycle, and the absence of vacuum further defeats its primary advantage.

AUTHOR'S CONCLUSION

The foregoing briefly states the case for the steam car, as we view it. We have said nothing of the gasoline situation, which it is well known is causing concern in the automotive industry, both as to quality and quantity, a concern that promises to become deeper with the increasing use of automobiles and particularly the most extensive increase of trucks, tractors and airplanes.

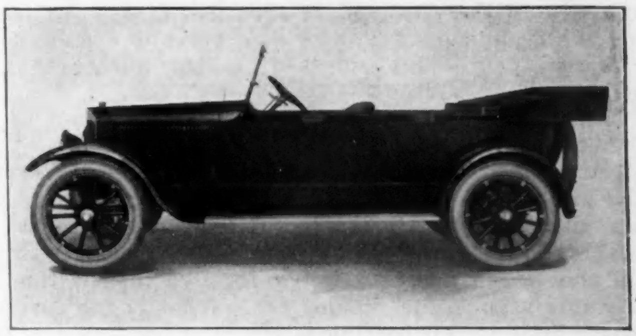


FIG. 8—MODEL 735 STANLEY SEVEN-PASSENGER AUTOMOBILE

We will not undertake to conjecture what the steam car would be today if abler minds than ours, the minds that have combated the difficulties of the internal-explosive engine, had applied themselves to this inherently simpler problem.

The time has come, we believe, when the industry must give pause to consider seriously our assertion that steam is not only the shortest but indeed the only route to automobile perfection.

Discussion on Steam Automobiles at Metropolitan Section Meeting

HUGO C. GIBSON (M. S. A. E.): The steam car is all right; it is fine! We know that for ordinary road purposes it will outdo the gas car, but we cannot afford to buy it.

Why do not the steam-car people give us an opportunity to prove what they claim? It is very easily done. A steam car contains tires, wheels, axles, steering gear, body, and a lot of other things, the same as a gasoline car; in addition to that it has one great advantage—its engine has "only thirty-seven working parts." Now, if it has only that number of parts why is there not a steam Ford?

I believe there is a great possibility in steam for automotive purposes. If steam is really a good propulsive means, let the steam exponents give us a steam plant for propelling an airplane through the air. I believe it would have fewer parts, the same as the automobile steam plant. The problem is really only one of utilizing heat, and I believe that the efficiency of a steam plant can be even higher than that of an internal-combustion engine, if loss of heat is prevented by proper insulation; in this particular respect the internal-combustion engine has the disadvantage that a very large proportion of the heat must be thrown away by arranged means—the cooling system. In the steam plant arranged means for holding the heat in must be provided; there is definite conservation of the heat units from the burner to the cylinder.

I would be very glad to hear what may be said as to the possibilities of propelling airplanes by steam.

MR. SCHLESINGER:—I would like to ask Mr. Warren and Mr. Sturgess about the provisions against the blowing out of the pilot light; does it happen? If so, what is the result?

I understand that the electric form of vaporization is new this year in the Stanley car. What is the current consumption of this heating coil?

I would also like to ask Mr. Thayer the definition of a unaflow engine. Reference was also made in Mr. Doble's paper to priming. We all know what priming means in gasoline practice, especially after this cold winter, but I have never heard it applied to steam engine practice.

Steam vs. Gas Engines for Airplanes

MR. EMORY:—I would like to answer Mr. Gibson's question about the use of steam for driving airplanes. The conditions required in an automobile are maximum torque with minimum speed; whereas the conditions in an airplane are approximately constant torque and constant speed. Of course, the latter is a condition for which a steam engine is not particularly well fitted—at least, not better fitted than a gasoline engine.

In regard to the question asked about the pilot light, I do not believe that a pilot light will be blown out by a blast of air, but unfortunately it is frequently blown out by absence of air.

I have driven the steam car a good deal—at present I am driving a gas car—but I must say that there is no comparison between the two. I would rather have an old Stanley car than a brand-new twelve. If the Stanley Company will only make a boiler that will not give out at unexpected moments, and a pilot light that does not go out just as it is needed, I think they will have what they refer to as the "perfect automobile."

Scale Formation in Steam Boilers

BENJAMIN F. TILLSON:—The questions I have apply more particularly to powerplant engineering, as a steam engineer sees them. A comment was made that 90 per cent efficiency was obtained in one of these steam plants. That is so unusual a result for steam plant engineering as to appear impossible because of the loss of 15 or 20 per cent of the heat units in the fuel, depending upon the temperature and volume of the gases leaving the furnace. I assume that the 90 per cent rating was in terms of the heat units in the actual boiler horsepower produced as against the heat units obtainable from the fuel used? The question of the possibility of scale forming in the boiler appears to me to be of more serious moment than this meeting has been led to believe. I would like to learn why the practice, generally found necessary in powerplant engineering, of eliminating all possible oil from feed water, does not also obtain in the practice of steam engineering as applied to small automotive units. If we do not eliminate oil from our boilers we get carbonized oil, which forms in the boiler tubes. Overheating and distortion of the boiler tubes result from the retardation of heat transmission caused by this deposit and disastrous failures have been due to this cause.

What provisions are there in steam cars for cleaning scale which does form in boiler tubes?

Answering the question raised in regard to the term "priming" in steam boiler practice, it is considered to be the mechanical carrying off of water with the steam and it is extremely objectionable.

Four Companies Developing Steam Cars

MR. BROWN:—There are now, to my knowledge, four different companies making progress in the development of the steam car. I say development, because all of them are capable of great improvement. Of those concerns, we have heard of two; a third is the Star Motor Company of Chicago, which has in operation on the road at the present time a steam truck that differs from the two described in that it has a water-tube boiler somewhat similar in general type to the Babcock & Wilcox. The combustion mechanism is similar to that of the Stanley. The other car has been designed and built at the Doble Laboratory of San Francisco by brothers of Abner Doble of Detroit, who originated the lighting of the fire by spark-plug. The boiler of the San Francisco Doble car is somewhat different from any of the other three. It is practically a very small circulating boiler with a very large economizer. The San Francisco Doble burner does not require any air pressure, has no small orifices to clog up, and offers some advantages.

The reason stationary powerplants have trouble with oil and these automobile plants do not is owing to the difference in the character of oil used. If we used the same class of oil in automobiles that is used in powerplants, we would burn our boilers inside of two or three days. The use of high-grade engine oil in boilers is not as harmful as the use of animal and vegetable oils.

Unaflow Engine Development

The definition of a unaflow engine was requested. In 1850 an engine was invented in which steam was admitted at the end of the stroke and exhausted at the middle, but it was not called a unaflow engine. Other inventions along that line followed until 1880; but none of them were called unaflow engines. In 1908 Johann Stumpf developed an engine of similar type, in which he achieved great economy such as had not been accomplished by any of the others; he called it a unaflow engine. That is the unaflow engine which has made a reputation for itself. With that definition of this type of engine, none of the engines described, as constructed by Doble or Stanley, are unaflow engines; they are simply copies of the 1850 engine which never was a success and which never was put on the market.

I am sorry to hear such claims of perfection, because I do not believe it does the cause any good to claim greater perfection than can be achieved in practice. Every one knows the advantages of the steam engine and every one who has had anything to do with it also knows the shortcomings of the steam combustion apparatus and boiler for automotive practice; great strides are being made to overcome these difficulties and when they are overcome—which I believe will be in the near future—then steam power is going to take its place.

S. N. CASTLE:—Most of the claims, as stated in the papers, have been commercial or "sales arguments" rather than engineering. Two points however do not appear to have been contrasted. Doble claims to get rid of the boiler scale by means of an oil film. What happens to the scale on the Stanley car? Second: Ability to run 2500 miles on one charge of water is claimed for the Doble car, while the Stanley people state that their car can run from 150 to 200 miles at the outside, on one charge. From what has been shown in the papers, the conditions of condensing are practically alike in the two cars with water charge apparently in favor of the Doble car.

ALEX SCHWALBACH:—The saying, "who shall decide when doctors disagree?" is quite true. Both Stanley and Doble use the same type of engine, but differ very radically as to their methods of producing steam and fire.

Multiplication of Cylinders in Gas Cars

There has been some discussion as to number of cylinders. The old "one-lunger" ran three-quarters of the time on the momentum it had gathered and on the stored energy from the flywheel. Maxwell produced two-cylinder automobiles, but the trouble with the two-cylinder engine was that it "ovalized"—by that I mean that the action of the piston on the lower side of the cylinder wore it out. We have the same state of affairs today in eight and twelve-cylinder V-shaped engines; every owner of an "eight" knows that finally its engine will be ovalized. We have the same condition in the two-cylinder steam car.

Now, as to price. If we had to limit ourselves to steam cars, there would be only one class of buyers, and they would rank in the $2,500 column.

The only reason two-cylinder cars were built after we got through with the "one-lunger" was so that we might get the price. But when competition became keen on that, Duryea introduced a three-cylinder, but that did not work right because it was "lopsided." Then came the four-cylinder, and the price was increased again. Then some one wisely said, "we will make a six," and the price was raised again. Then came an eight. Up went the price again! Every cylinder meant more money. Now we have the twelve-cylinder—and another advance in price. The most pertinent example of this price trend is the "one-lung" Cadillac. Made with one cylinder, it cost from $600 to $700. With four cylinders the price was doubled; then came eight cylinders and another doubling of price. One reason for increasing the number of cylinders is not because of overlapping impulses, but because of overlapping prices.

EARLY STANLEY STEAM CARS

MR. WARREN:—When we started in business in 1896, Mr. Stanley had the same great idea as Henry Ford, that there is an infinite number of people who would pay five or six hundred dollars for an automobile, so we put our first cars for sale in 1898 at a price of $600. At that time Haynes and Duryea cars were selling for from $1,200 to $3,000. In 1910 we built a 10-hp. car, with a speed of 60 m.p.h., and sold it at $850 and we made some money on it, with a production of only five hundred of that model. That car was not equipped with a windshield, to be sure, and many of the accessories that people now demand. It shows, however, what can be done in the matter of price. We were building three different sizes of cars. In 1914 we decided that it would be better business to concentrate on one model. Our demand showed that the 20-hp. car was the most popular. In 1915 that car was selling for $1,975; now it is selling for $2,800 owing to the advance in the prices of material. There is no doubt in our minds that the steam car can be built of the same quality and in the same production for less money than any other car.

There is much to be said about steam airplanes, but I do not believe we are quite ready to say it. I happen to know of a little activity in that line, but I was asked not to say anything about it.

Pilot and Electric Ignition Difficulties

Someone spoke about the pilot difficulty. There is difficulty with every type of car. Let us see what is the difference in this respect between the steam and gasoline cars. In the steam car we have one pilot light that burns steadily; it is not mechanically operated and does not depend upon electricity. On a twelve-cylinder car there are twelve electric pilot lights which are mechanically operated and they are expected to ignite themselves and go out 25 times a second—a total of 18,000 times a minute. Which problem is easier?

MR. STURGESS:—Mr. Schlesinger inquired about the current consumption required for starting the pilot light. About 200 amp. for 15 to 20 sec. is the maximum flow. This is about the same current flow used on the average gasoline car, but the battery is used only very rarely—certainly not more than once a day—so that the net load on the battery is very much lower.

Life of the Stanley Boiler

Mr. Emory asked why we do not make a good boiler, and referred to its life. We contend that we do make a marvelously good boiler. The average life of our boiler is four to five years; I say average—that is, taking a very large number of boilers, a thousand or more, into

consideration. Four or five years we consider a very good life for the boiler, and it compares well with the life of many vital parts of gas cars. It should be borne in mind that the boiler is about the only part of the steam car that wears out—the engine is practically indestructible, and there is no transmission. The wear on the other parts of the car is so low that a life of four or five years on a boiler does not result in a heavy annual repair charge.

Importance of Using Proper Water

In any engineering field there are occasions where we have exceptional cases of trouble, but it is erroneous to regard those as typical. There was one such case where a man had a boiler he could not make last for more than three months. We had to put in a new boiler, which again failed. The case looked so bad that we sent a special engineer to investigate. We knew that there were many other Stanley users in that same town, and they had no trouble. We finally found that he was using water from a well that was full of magnesia and lime, and he never blew off his boiler, so of course he had trouble. After we pointed that out to him he ceased using that water, and had no more trouble.

Kerosene Mixed With the Lubricant

As regards oil causing trouble in the boiler, we as engineers are all thoroughly familiar with the old axiom that at all costs oil must be kept out of steam boilers. It is well known, however, that the practice of putting kerosene in boilers acts as a deterrent to the formation of scale arising from the inclusion of oil and while it is not very practicable to put much kerosene into a large boiler, yet I believe the practice is not adopted as much as it might be. We make a practice of mixing kerosene with our lubricant and as a consequence the oil—irrespective of what it ought to do, does not cause any trouble. I attribute this to the fact that the kerosene gets on the tubes first and the oil does not have a chance to adhere. Of course, we make a practice of blowing off fairly frequently, and I think those two facts account for the circumstance that in practice we do not have any trouble from oil in the boiler.

Efficiency of the Stanley Powerplant

Mr. Tillson inquired concerning Mr. Doble's claim of 90 per cent efficiency. Mr. Doble will answer that, but I may say that in tests on our 4-by-5 stock engine, working with about three-eighths cut-off, and using superheated steam, we have frequently obtained steam consumptions of from 16 to 17 lb. per hp. Gasoline engine men probably will not appreciate this point quite as well as steam engineers; steam consumptions of 16 to 17 lb. have been associated with steam engines of the most economical type. With a condensing engine running under 28 in. of vacuum, a rate of 13 to 14 lb. of steam per hp. is considered very good. I attribute our small engine's excellent performance to the high superheat, to the perfect insulation against radiation, and to one or two other minor constructional causes. This performance works out to 77 per cent efficiency, based on the Rankine cycle, which is surprising for so small an engine. Those tests were carried out under strict scrutiny with calibrated instruments, and independently checked by many engineers; in fact, during some of our initial tests there was so much doubt about the results that we had Professor Miller, of the Massachusetts Institute of Technology, verify the results.

Water Tank Capacity

The figures of water consumption (miles per tank of water) which we gave, we regard as conservative, and those which will be experienced every day by the average automobilist. We do not know whether Mr. Doble's figures are on the same basis. The Doble design uses a fan to augment the condensation. The use of a fan was carefully considered by us, but it was regarded as an added complication, involving more parts to wear and greater cost, which are not warranted. If a car can run 150 to 250 miles on a tank of water, that is about all that is really required, because people do not often go very much farther than that in one day; and when they are in the garage there is absolutely no objection to refilling the water tank.

Two vs. Eight Cylinders

Mr. Schwalbach seemed to think that the two-cylinder engine is subject to criticism. Two double-acting steam cylinders produce exactly the same number of working strokes as an eight-cylinder gasoline engine, and a sustained turning effort equal to several times that from eight cylinders, owing to the sustained pressure in the steam cylinder as compared to the explosive action in the gas cylinder. Therefore it is obvious that there is no need of increasing the number of cylinders above two. The two cylinders give a perfect turning moment.

Steam Car Problems Are Simple

Mr. Brown charged us with claiming greater perfection than can be achieved in practice. I hardly imagine he alludes to our claims on the score of performance. Perhaps Mr. Emory's obviously sincere remark that he would rather drive an old Stanley than a brand-new twelve may be quoted as typical of universal assent to such claims. But Mr. Brown undoubtedly referred to constructional problems. We have never claimed for the steam car complete freedom from trouble—but bear in mind that to the gas man these are unfamiliar troubles, and therefore loom big—just as to us the troubles of carburetion, ignition (which Mr. Warren correctly presented as a mechanically controlled electric pilot to be lighted and extinguished 18,000 times a minute) cooling, and terrific engine speeds, seem to us appalling. We *do* claim that our problems are simple, our troubles are less, and cost of maintenance lower.

As regards Mr. Schwoldach's remark on doctors disagreeing, perhaps the respective ages and size of clientele of the "doctors" should be taken into consideration.

(Discussion contributed after adjournment.)

R. H. Thayer*:—It is to be regretted that much of the discussion took the form of exploitation of personal opinions as to who could or could not properly design and construct an engine of the unaflow type, and as to who was or was not the inventor of means of igniting sprayed liquid fuel whereby the use of the obnoxious pilot light might be avoided.

A discussion as to the real merits of the unaflow and counterflow types of steam engine would have been of extreme interest and real value. The statement that no steam car builder had made or used a real unaflow type of engine is simply an expression of personal opinion without materiality or importance. The remarks as to who could best build such a type of engine are equally unimportant.

*Technical Manager, Doble-Detroit Steam Motors Company.

Johann Stumpf, in 1908, undoubtedly contributed materially to the efforts of the man of 1850 in the development of the unaflow type of engine, and our recent efforts might have been held in higher repute had they not been attempted without the aid and assistance of the disciples of Johann Stumpf.

The question was raised as to the meaning of the term "unaflow." This can be explained by comparing it with "counterflow." In the unaflow type of engine the steam enters the end of the cylinder through a port in the usual manner and forces the piston ahead, but instead of exhausting this spent steam by causing the piston on its return stroke to drive the steam out through the same port through which it entered (thus compelling it to counterflow) the live steam in the unaflow cylinder follows up the piston and is exhausted through ports in the cylinder walls located at about its center of length; these ports are uncovered by the receding piston head. Thus the steam is caused to flow constantly in one direction, giving rise to the term "unaflow" as distinguished from "counterflow."

As to the real merits of the counterflow and unaflow types of engine, much can be said in favor of each, especially with respect to their adaptation to steam-propelled vehicles. The determining factor with us, thus far, has been one more of expediency as prompted by physical conditions. Since we are using, with highly satisfactory results, the unaflow type in passenger cars and the counterflow type in our steam trucks, we are committed to neither.

Mr. Emory, who, as he says, has driven a steam car a good deal, but at present is driving a gas car, made some most interesting statements that were of particular interest for two reasons: First, they corroborated the statement and voiced the sentiment of hundreds of other drivers of steam cars who later abandoned them for the gas cars; that is, he who has once experienced the pleasure, satisfaction and contentment arising from operating the steam car seeks in vain for a like experience in connection with a gas car.

Problems Involved in the Doble Combustion Mechanism

The idea of means whereby the pilot light might for once and all be eliminated involved something more than the mere discovery of means "of the lighting of the fire by spark-plug." The earlier patents—even the expired patents—abound with disclosures involving the igniting of liquid fuel by a spark. The problem was not the mere ignition of non-volatile liquid fuel such as kerosene by a spark, but rather the successful and repeated ignition, by spark, of sprayed kerosene mixed with the enormous volume of air necessary to insure combustion to the utter exclusion of soot, smoke and smell. Nor did the problem cease with the discovery of means for initiating combustion in so rarefied a mixture. It was found that with the burning of a sufficient quantity of fuel mixed with the proper amount of oxygen to produce the necessary temperature whereby the excessive and sudden demands for steam would be satisfied, an enormous volume of flame resulted. It was the successful confining of this voluminous flame in the necessarily limited space in the fire-box, 20 in. square and 8 in. deep, that proved to be the greatest problem of all, and as we glance back and review the efforts of engineers, it becomes evident that it was this seemingly impossible task of properly confining the open flame without interfering with proper combustion that drove them all to vaporizing the liquid, producing a gas which was at once readily ignited and easily confined in the necessarily small fire-box such as could be adapted to a steam-propelled vehicle. This pregasification, however, necessitated the use of a preheating means, including the troublesome pilot light.

Our method of igniting and burning cold-sprayed kerosene in the fire-box of our special design enables us to generate from three to four times the number of heat units that is possible in the same size of fire-box when vaporized fuel is burned.

Small Steam Cars

Mr. Gibson is not alone in his expressed desire for a small steam car, and our summing up of the advantages of the steam car from the manufacturing standpoint was intended to convey the idea of the possibility of building a small steam car which would be superior in performance to a car with the most highly developed type of internal combustion engine. It will be only a matter of a comparatively short time before a small, moderate-priced car will be on the market. Mr. Gibson also asks as to the possibilities of propelling airplanes by steam. While we are not in position to make any very definite statements in this respect at the present time, we do wish to say that this field has been given a great deal of thought and most satisfactory progress has been made.

Priming Avoided in the Boiler

In answer to Mr. Schlesinger's question in regard to priming, the term priming in steam engineering practice is used in an entirely different sense than when applied to a gasoline engine. In a steam boiler "priming" or foaming is the intermixture of particles of water with the steam in the upper part of a boiler, passing into the steam pipes and cylinders. Priming is caused by irregular evaporation. As Mr. Tillson has already explained, priming is extremely objectionable. To recall the connection in which the term priming was used, the fact should be borne in mind that the boiler data were computed in a laboratory test where the evaporation was noted in a boiler without a superheating coil, whereas in our present boilers with a superheating coil we are getting at least 20 per cent greater evaporation *without priming*.

Over-all Boiler Efficiency

Mr. Tillson's question as to the basis on which we arrive at a figure of 90 per cent over-all boiler efficiency can be answered as follows:

Water evaporated, lb. per hr.	630
Superheat, deg. fahr.	25
Total heat (Mollier diagram), B.t.u. per lb.	1245
Temperature of feed water, deg. fahr.	62
Total heat above feed water temperature, B.t.u. per lb. = 1245 — 62 =	1183
Fuel burned = oz. per min.	11
Fuel burned = lb. per min.	0.6875
Fuel burned = lb. per hr.	41.24
Heat value of the fuel, B.t.u. per lb.	20,100

$$\text{Efficiency} = \frac{1183 \times 630}{41.24 \times 20100} = \frac{74600}{82700} = 90 \text{ per cent}$$

Action of the Lubricating Oil with High Temperature Steam

In regard to the action of lubricating oil with the steam, Mr. Tillson lost sight of the fact that we mentioned particularly that gas-engine cylinder oil was used. Owing to the high temperature and pressure in our boiler, this oil does not exist as a liquid, but rather is present as a gas. In going with the superheated steam to the valve chest and cylinders the temperatures become low enough to condense a part of the oil to a liquid, which properly lubricates the moving parts. Passing with the exhaust steam to the condenser, both steam and oil are converted into liquid form and are fed again into the boiler. To quote the statement in our paper, this oil is very thin at 490 deg. fahr., and the coating of oil which forms over the entire inner surface of the boiler is consequently so thin as to have a negligible effect upon the heat transference conditions. These observations are borne out by actual practice in our powerplants, and are verified as well by experiments conducted by Prof. Chas. E. Ferris of the University of Tennessee, Dr. P. H. Conradson, and other authorities.

The following quotations are from a report, dated Aug. 10, 1917, made by Professor Ferris:

"When I made a recent examination of the Doble-Detroit steam car, one question which I particularly wished to settle was the effect of introducing lubricating oil into the feed water. It has long been an established principle of mechanical engineers that oil introduced into feed water for the steam boiler is positively injurious. My own experience as an engineer supports this theory.

Oil Is Present as a Gas

"In my opinion, oil cannot exist as a liquid under the high temperature and pressure in your boilers, and it is present as a gas, this gas going with the superheated steam to the valve chest and the cylinder. The temperatures here are low enough to condense a part of the oil to a liquid which properly lubricates the moving parts. The exhaust then passes to the condenser, where both steam and oil are completely condensed into the liquid form and then are fed into the boiler.

Critical Temperatures of Oils

"To illustrate this theory I submit a diagram worked out from steam tables for pressure from 100 to 1200 lb. per sq. in. The ordinates represent the pressure and temperature of saturated steam, and the abscissas the volume of 1 lb. of steam. The curve *CD*, which is very nearly a straight line, is for the liquid; the curve *AB* is for the vapor. I have continued these curves in dotted lines to a pressure of about 3200 lb. and a corresponding temperature of 706 deg. fahr. It is well established by many scientists, from actual laboratory experiments, and by mathematicians, that when a temperature of about 700 deg. fahr. is reached the density of the water is the same as the density of steam. Or, to put the matter in a different form, the latent heat of the water becomes zero at this temperature, and there is no physical difference between the water and its vapor. No heat is required to boil the water at this temperature. If more heat is added the steam becomes superheated at once. This is known as the critical temperature. Scientists have determined the critical temperatures of a large number of simple and compound substances. For example, the critical temperature of carbon dioxide is 125, and of sulphur dioxide 311 deg.

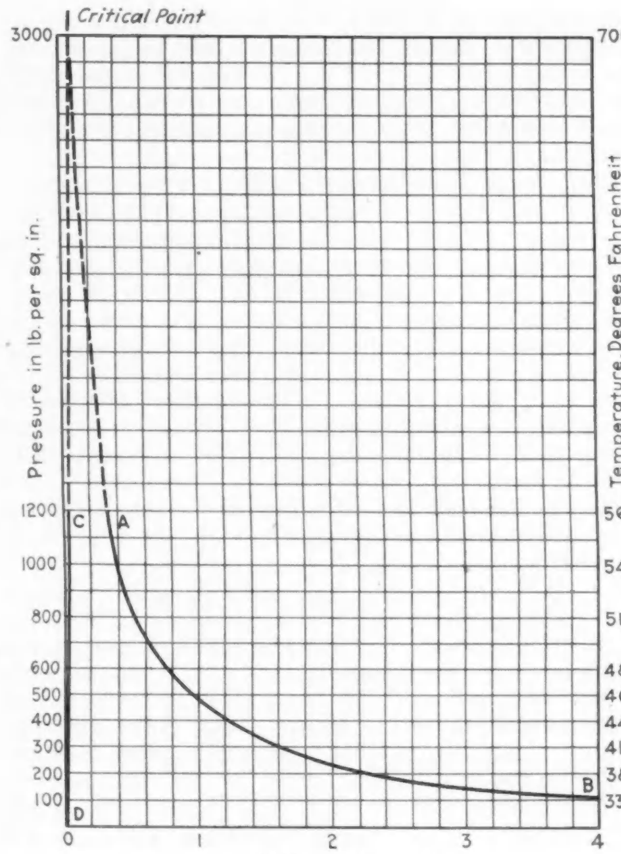


Diagram Showing the Critical Point of Water

"Apparently no experimental data are available to show that there is a similar critical temperature for the lubricating oil which is used with superheated steam. Very serious difficulties are presented in determining such a point because of the phenomenon known as the 'breaking up' of the oil by the action of the heat. Light oils are thrown off in the form of vapor, leaving the heavier oils with new chemical formulas, new molecular weights and new densities. Bloxam's Chemistry, sixth edition, page 737, gives some interesting data along this line. In general, for each change of CH_2 the boiling point changes approximately 36 deg. fahr. Bloxam carries these changes for the paraffins to the composition of $C_{16}H_{34}$, giving a boiling point of 535 deg. fahr.; for the olefins, with the chemical formula $C_{16}H_{32}$, the boiling point is 530 deg. fahr. This does not prove that the distillation has been carried to the limit, and that the final resulting oil is given by the formulas quoted above; however, this would at least be an indication that at the temperature of 550 deg. fahr. the oil becomes a vapor.

"Dr. P. H. Conradson, chief chemist of the Galena-Signal Oil Company, reported the results of experiments before the Cincinnati Railway Club. I refer to the proceedings of this club, dated May 11, 1915, pages 375 to 377. Doctor Conradson introduced lubricating oil in the form of a spray into superheated steam, passing this through glass tubes into the steam chest and cylinder. He states that the mixture of oil and superheated steam in the tubes showed gray. Without doubt, superheated steam alone would be colorless. When the temperature was raised to 550 deg. fahr. the gray color disappeared, indicating the oil present had changed its physical state, and was no longer present in small globules, *but had become a vapor.*

He carried the experiment up to a temperature of 800 deg. fahr., and stated that above 550 deg. fahr. no color due to the presence of oil appeared. He proved the presence of the oil by opening the stop cock and blowing the superheated steam on a sheet of white paper. The experiment was not conducted with the purpose of showing the critical temperature of oil, but as conclusive proof that at a temperature of 550 deg. fahr. the oil was in the form of a vapor. Dr. Conradson states that he always considered 550 to 560 deg. fahr. as the critical temperature of valve oil used with superheated steam.

In a recent publication of the Road Foreman's Association the engineer of the Detroit Lubricator Company states that it is his opinion that lubricating oil in the presence of superheated steam changes to a vapor at a temperature of something above 450 deg. fahr.

"I discussed this question with Eugene Giesler, research engineer of the Fulton Company of Knoxville, Tenn. The temperature-regulating devices manufactured by this company are based on the predetermined boiling points of volatile liquids. Mr. Giesler has given the subject an exhaustive study. He gives the opinion that lubricating oil, used with superheated steam at a temperature of 600 deg. fahr. *can exist only as a vapor.*

"There is yet another explanation to the freedom from injurious action in lubricating oils in the Doble-Detroit steam car. The rate of circulation of water and steam is rapid enough to set up a scouring action which would remove the film of oil should the oil be present in the form of a liquid.

"I wish to place particular emphasis upon the statement of Doctor Conradson, based on actual experiments, that mineral oil used to lubricate engines cannot exist as a liquid in the presence of steam at 600 lb. pressure with approximately 200 deg. fahr. superheat, therefore raising its temperature to about 600 deg. fahr."

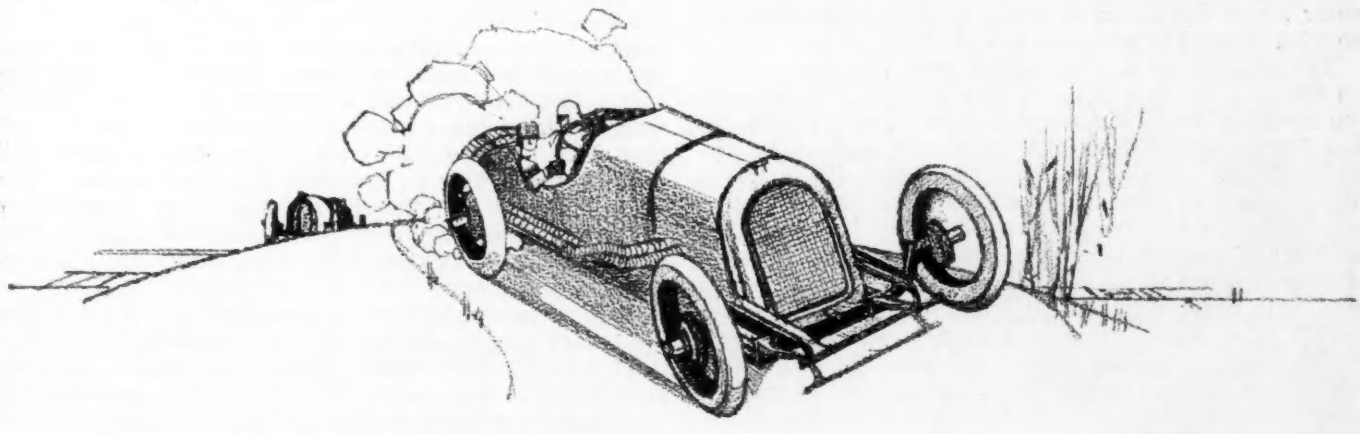
It would be a repetition of our statement also to refer again to the lack of scale formation. Whatever small scale formation might occur would either reach the water tank, where it would remain, or it would continue in circulation.

Water Tank Capacity of the Doble Car

Mr. Castle asks about the mileage obtained on one filling of the water tank. Some builders of steam cars formerly used no condensers, and others used a tubular type of condenser, but the low mileage on water supply has always been a serious drawback to steam cars. With our closed condensing system and the use of a honeycomb type of radiator we obtain a most satisfactory mileage. The reason, as has already been explained, is that a honeycomb type of radiator can be used in our system where formerly it had been deemed unavailable.

Not satisfied with a better distance on one water supply than formerly had been found possible, we conceived the idea of driving a fan by means of a turbine operating on exhaust steam.

The advantages of the turbine-driven fan are obvious. When the car is pulling through heavy sand or on a long, continuous grade, there is, of course, a greater volume of exhaust steam, so that the speed of the fan is increased, regardless of the speed of the car, and gives us a very much greater efficiency of condensation at the time when it is needed.



Lubrication of Tractor Engines

By W. G. Clark* (*Member of the Society*) Minneapolis Section Paper

LUBRICATION is one of the most important factors entering into successful tractor operation. Fully 75 per cent of tractor field troubles can be directly or indirectly attributed to faulty lubrication.

Lubrication in general covers such a broad field that a paper of this kind must necessarily be limited in scope; I shall touch, therefore, only upon that part of the subject that has to do with the engine, dwelling especially upon the relation of lubrication to carburetion and ignition and upon the importance of proper oil selection. The latter subject, that of proper oil selection, offers a big opportunity for more extensive experimental work than has been done in the past, because it is the lack of data on this subject and the neglect of manufacturers to recognize and emphasize its importance that is responsible for a large part of field lubrication difficulties.

In designing an engine the method of oiling should be determined by the type and by its class of service. Unfortunately, the deficiencies of engine design and of fuel vaporizing methods often necessitate the selection of an oiling system which may not be the best for the particular type of engine on which the designer is thus forced to use it. This is particularly true of some horizontal engines, in which the fuel is introduced in a comparatively raw state and which rely largely on compression for vaporization. Under such conditions vaporization can at best be only partial, and the use of anything but a non-circulating system is prohibited because of the certainty of oil dilution.

Types of Oiling Systems

There are many systems and combinations of systems used in tractor-engine lubrication. I do not intend to enter into a discussion of oiling systems in general, but do wish to touch briefly on a few of them.

The old-time wick oiler, which was used successfully on some of the first engines, has become obsolete with the advent of heavy fuels and modern oiling methods. It has been supplanted in the horizontal engines by the self-contained single-flow force feed and the external unit mechanical oiler. Naturally the horizontal engine is not adaptable to the splash system, but if it were the methods of carbureting low-grade fuels found on some of these engines would prohibit its use. Since the oil is used only once, a heavy oil consumption must be expected. Yet when proper carburetion methods are employed these mechanical oilers and non-circulating systems are as efficient as any other. Some vertical engines make use of mechanical oilers for similar reasons, which to me seems attempting a cure without getting at the cause of the difficulty.

The circulating force feed, the splash, and various combinations of these, are the systems by far most commonly used in vertical tractor engines. The splash system is especially easy to regulate, easy for the average operator to understand and care for, and, when unhindered by fuel troubles, is economical and well deserving of its present wide use.

Selection of Lubricant

The selection of an oil, like the selection of an oiling system, ought to be determined by the type of engine and the service required; yet we find thousands of tractor operators using any oil sold as a "motor oil" because they think that if they pay a big price for a so-called motor oil it must be all right. I know of no greater mistake in the tractor field today than this common belief that any oil is good oil if the price is high enough or if it is bought in a sealed tin. The farmer is not altogether to blame, because there are no practical tests he can apply to determine an oil's suitability for his engine, unless he actually tries it, which often proves costly. Too little attention has been given by the tractor manufacturer to finding out the best oils for his engine and insisting on their use. This should be done thoroughly and accurately by every tractor maker if only to insure the satisfactory performance of his product. I know of many tractors that have been unjustly condemned simply because the service man in delivering the machine failed to impress on the purchaser the importance of correct oil and care.

The increasing use of low-grade fuels has drawn more attention to the oil question, and we now find that some of the tractor makers are devoting more space in their instruction books to this long-neglected but vital factor. Some of them were forced to do so as soon as they commenced to use low-grade fuels. A horizontal engine in which the fuel is not thoroughly vaporized before admission to the cylinders must use a very heavy-bodied oil to prevent immediate and excessive wear, because the dilution of the lubricant by the ever-present raw fuel lessens its lubricating qualities so rapidly that such an oil is required to furnish lubrication after its partial dilution. The fact that kerosene acts as a solvent of oil more readily than gasoline partly accounts for the fact that with a heavy-bodied oil one of these engines will actually run better on kerosene than on gasoline. The thick heavy oil is not cut by the gasoline, thus giving greater piston drag and less complete combustion of surplus oil, and often resulting in greater carbon formation and less power.

To illustrate this I will cite a case that came under our observation some time ago. A firm manufacturing a large single-cylinder horizontal engine stated enthusiastically that the engine was developing considerably more power on kerosene than on gasoline, even when the gasoline was unheated. We investigated and found that such was a fact so long as the very heavy oil was used, necessitated by the defective carburetion of the kerosene. However, when a lighter and more suitable oil was used for gasoline the situation was reversed, which serves to show how easily one can be led into erroneous conclusions because of the close relation of carburetion to lubrication.

*Mechanical Engineer, Wilcox-Bennett Carbureter Company.

The selection of suitable oils for any given type of engine should be made after careful laboratory tests, supplemented by equally careful field tests. The right kind of laboratory tests require considerable apparatus and are costly, so that certain recent developments in physical chemistry, of means by which the performance of any oil can be accurately predicted, will do much, if adopted, toward eliminating some of our lubrication difficulties.

Tests on Lubricating Oils

In 1913 and 1914, while with the experimental department of the Emerson-Brantingham Company, E. R. Greer and I conducted some tests on lubricating oils by a new method, which yielded some interesting results.

These tests were not intended as a scientific investigation of lubricating oils for gas engines in general, because they were confined to one engine and one speed, so that the results, while accurate in method, are applicable specifically only insofar as that engine is concerned. The following description of apparatus and procedure is a partial excerpt from my report made at the time, for which I am indebted to A. Krieg, chief engineer of the Emerson-Brantingham Company:

"The engine used in these tests was a standard stock job, 5 by 7 in., four-cylinder, four-stroke cycle, vertical, designed for heavy-duty tractor work. It was placed in the laboratory in September, 1913, and used for experimental work until the middle of December. By that time all the bearing surfaces had been thoroughly worked in and the friction of the moving parts had become practically constant. The engine was thoroughly cleaned and scraped and the connecting-rods, valves, timing, etc., checked over and put in the best of condition. Since the success of any comparative test depends upon the exact duplication of every condition for each successive test, it was considered necessary to remove the water pump and governor; the water pump because it was mounted on the crankshaft with an adjustable stuffing box, which was likely to vary in adjustment and so change the friction of the engine. The governor was replaced by a rod, which locked the throttle wide open where it remained throughout the duration of all tests.

"The oiling system was of the pump feed, circulating splash type, in which the oil is drawn by a cam-driven plunger pump from the oil reservoir and return to the crankcase. Thermometer wells were placed in the oil reservoir, intake manifold and in the engine housing between cylinders 2 and 3, projecting down into the crankcase.

"The cooling was accomplished by an electric-motor driven gear force pump circulating the water from a large supply tank and cooling screen or through an open 52-gal. barrel as desired. By an arrangement of valves and piping it was possible to control the water temperature and regulate the flow. Two pressure gages in the cooling system also made it possible to maintain the same rate of flow throughout all the tests. Thermometer wells were placed both in the inlet and outlet of the cooling system, and oil baths were used for the thermometers in all cases.

"The fuel used was 57-deg. motor spirit, purchased all in one lot to insure uniformity. It was fed to the carbureter by gravity from a 20-gal. tank with provision for measuring the fuel consumption accurately.

"The dynamometer was a Diehl electric cradle-type machine with which could be measured small variations in load ranging from 0.0038 hp. at 100 r.p.m. to 0.057 hp. at 1500 r.p.m. The action of this machine depends upon the magnetic reaction between the field and armature; the amount of torque is registered by an arm with a knife edge acting at a fixed distance from the shaft center upon a sensitive Fairbanks scale. Since the torque is dependent upon the speed of the armature and the strength of the field, which was separately excited and under exact control, the accuracy is independent of the electrical efficiency of the machine; thus the speed and load can be varied widely without the error involved in the use of efficiency and calibration curves.

"The speed was obtained from a Schuchardt & Schutte tachometer driven from the dynamometer shaft and checked by a Veeder counter on the same shaft.

"The actual testing period for each oil was about 10¾ hr., and was divided into three parts, namely: Cold Friction Test, Power Test and Hot Friction Test, run in the order given.

"After each oil was tested the engine was subjected to a thorough cleaning to remove all traces of the oil. The oil reservoir was drained, washed out with kerosene and wiped dry. The crankcase was similarly treated and then clean kerosene was put into the oiling system. The engine was then driven for a time by the dynamometer until the kerosene had washed all through the bearings, after which the whole system was again drained and wiped out. This process was repeated with clean kerosene until the kerosene drained from the engine contained no trace of oil. The engine was then allowed to stand several hours to drain thoroughly, after which it was wiped dry before putting in the new oil. This cleaning process was followed after every test.

Cold Friction Test

"The first part, the cold friction test, consisted in measuring the friction horsepower of the engine with the new and unused oil. This was done by driving the engine at its rated speed of 700 r.p.m. with the dynamometer and obtaining the change in friction as the heat of compression warmed the oil and jacket water. Friction power readings were taken every 15 min., together with temperature readings from the crankcase, oil reservoir, water-jacket, intake manifold and room. The 15-min. readings were continued until the friction became practically constant and the temperature changes so small as to be inappreciable.

"This part of the test might have been continued until all the temperatures became constant, but the value of the readings would not have been worth the time required to get them.

"By regulating the speed of the water pump and watching the pressure gages in the water line, it was easy to duplicate the rate of flow of the cooling water for each test, so that any change in the heating or cooling rate in a test could be directly attributed to a thermal difference in the oil itself. This idea of duplication of every essential condition was kept constantly in mind throughout the tests, and every effort was made to eliminate all variables, so that all changes of friction or fluctuation of any sort might be charged to the lubricating oil.

"The object of the cold friction test was to measure the comparative lubricating values of the oils when new; when considered with the third part, the hot friction test, it forms a good basis for the comparison of the stability of an oil's lubricating value.

Power Test

"The second part, the power test, consisted of a 5-hr. continuous power run with wide-open throttle and maxi-

mum load. The 5-hr. run was chosen because it was estimated that when the engine ran under full load for 5 hr. continuously, the oil had been subjected to the same amount of work as in an ordinary day's run in the field. During this part of the test the temperature of the cooling water was maintained about 180 deg. for all the oils and readings were taken as in the first part as well as those required to measure the fuel consumption.

"At the end of the 5-hr. run the third part of the test was carried out. The cooling system was heated to boiling temperature and the amount and rate of flow of the water regulated to be the same as in the first part. At this point the fuel and ignition were cut off and the engine kept running at the same speed by the dynamometer. Friction, horsepower and temperature readings for the first 20 min. were taken at 2-min. intervals, because of the rapid temperature drop and friction increase during the first few minutes. The intervals between readings were later increased to 15 min. as in the first part, and the run continued until the oil and water cooled down to a point 10 or 15 deg. above the final readings in the first part.

"This part of the test was really the most important of the three as it showed the difference in lubricating value of the various oils after being used in the engine and exposed to heat. This serves as a measure of the stability and lasting qualities of the oil.

"At the end of the third part of the test the oil consumption was measured and a pint of the used oil taken for analysis.

"Upon the completion of the tests, check runs were made on several of the oils to ascertain if there had been any change in the engine friction. This second series of tests checked so closely with the originals that we were confident that the engine friction had not changed.

"There were twelve oils used in the tests, some being especially compounded for the engine and the others being common commercial motor oils such as are used in tractor work. No attempt was made to obtain oils of any special base, so that of the twelve tested, two were from Pennsylvania paraffin crudes, five or six from Mid-Continent crudes and the rest from various semi-asphaltic base crudes.

Results of the Tests

"The data acquired were plotted in diagrams in three groups called the Temperature-Power, Time-Temperature and Time-Power.

"The Temperature-Power group showed the variation in friction horsepower of the engine with the change in temperature during Parts 1 and 3.

"The Time-Temperature group showed the time rate of temperature change of the different oils during Parts 1 and 3.

"The Time-Power group was merely a graphical representation of the entire test in its chronological order, showing the variation in friction and maximum power throughout the tests.

"The temperatures used in plotting these diagrams were those of the water-jacket and crankcase, a different set for each temperature."

The variation in the friction of the engine with the different oils was marked and easily measurable. Two oils of the same gravity and viscosity showed as much as a horsepower difference in friction of the engine, and two oils that gave practically the same results in Part 1 were entirely different after being subjected to heat for 5 hours.

One of the oils, similar in physical specifications to several of the others, but used chiefly for line shafting, was tested just to see how it would compare. It gave good results in Parts 1 and 2, but Part 3 showed that the 5-hr. power test had almost totally destroyed its lubricating qualities.

If there were such a thing in petroleum derivatives as an ideal oil, its temperature-power diagram would be a horizontal line; in other words, its lubricating value would be the same at all temperatures within the limits of its use in engines. Those oils whose temperature-power diagrams had the least slope, proved to be the better oils.

In the Time-Temperature group the general slope of all the curves was practically the same, although the maximum and minimum points were different. Since the slope of these curves is a measure of the heating and cooling rates during the various tests, the uniformity of slope indicates that the rate of circulation of the cooling water was uniform. These diagrams might also be used to indicate the thermal capacities or insulating qualities of the different oils, although sufficient data were lacking to warrant any such conclusion.

Factors Determining Lubricating Efficiency

The comparison of the oils was based on three factors: Lubricating efficiency, oil consumption, and fixed carbon and insoluble content. Lubricating efficiency was subdivided into three parts: First, average maximum power delivered by the engine with each oil; second, the change in friction horsepower per degree change in temperature; and, third, the average friction between the temperature of 90 and 200 deg. By giving the three separate parts of lubricating efficiency equal weight with oil consumption, fixed carbon and insoluble content, lubricating efficiency as a whole comprises three-fifths of the total comparative rating of each oil, which seems a fair proportion. I will not detail further the methods of scoring used in these tests. The complete report and all the data were printed in *Internal Combustion Engineering*, May 27 and June 3, 1914, published in London.

Chemical and Physical Tests

Samples of each oil were taken both before and after testing in the engine and were analyzed by a chemist. A careful study of the properties of these oils in conjunction with the results of the tests fails to reveal any distinct relation between the physical properties of an oil and its value as a lubricant. The nearest approach to such a relation seemed to lie in the fixed carbon and insoluble content, as the oils that gave the best results had the least amounts of these elements. However, we did not feel justified at that time in drawing any such conclusion, but recent developments in physical chemistry of oils indicates that our beliefs were not unfounded.

These tests proved to us that the performance of an oil in an engine cannot be predicted accurately by the usual physical tests, as given in ordinary oil specifications. Of course the viscosity and cold-test properties must be suitable for the service intended, but in themselves they are no basis for judging an oil's utility.

Actual laboratory and field tests are the best gages of an oil's suitability for an engine and will continue to be, until some newer and simpler method is worked out. Such a method, which is chiefly a chemical one, was described in a paper by C. W. Stratford entitled, Standardized Specifications for Lubricating Oils, which appeared in the February issue of The Journal. I heartily recommend a careful reading of Mr. Stratford's paper be-

cause it seems to offer a simple and logical solution of many present problems in oil testing. Mr. Stratford corroborates our conclusions regarding the inefficiency of the customary physical tests as criteria of lubricating suitability, and he also emphasizes the importance of a minimum of carbonaceous insolubles in oils.

Importance of Clean Oil

Proper care of the lubricating system can be summed up briefly in three words: Keep it clean! It seems to be a difficult matter to impress upon the average operator the fact that lubricating oil wears out and gets dirty, even though protected from external dirt. The average operator forgets that the tractor oil is subjected to six or seven times the service that an automobile oil gets in the same length of time, and as a result neglects the more frequent cleaning and replacing required. The best oil that can be obtained will wear out and become gritty with use and must be thoroughly cleaned out in order to protect the engine bearings.

Putting fresh, clean oil into a dirty crankcase with worn-out oil is a waste of good oil; the old contaminates the new in a short time. The frequency of cleaning is augmented by incomplete or poor vaporization methods, because of oil dilution. It is a regrettable fact that too often a tractor operator gages the condition of his oiling system by the quantity of oil in it rather than by the quality and condition of the oil; this accounts for many burnt-out bearings, which were apparently flooded with oil.

Spark-Plug Trouble Caused by Oil

The spark-plug question is worthy of mention in connection with lubrication. There are on the market many good spark-plugs for every class of service, but many of them have been, and are, unjustly condemned, because of poor selection, improper location, poor carburetion and dirty lubrication.

If the right type of plug is used, if the carburetion is even approximately correct and if the lubricating oil is kept clean, a spark-plug will never foul. That statement is backed by many personal experiences and hundreds of field reports. I know of case after case where spark-plug trouble was totally eliminated by simply washing out a dirty crankcase and using fresh, clean oil.

Author's Conclusions

The problem is one of cooperation among gas-engine engineers, ignition and carbureter makers and oil refiners. To insure lubrication efficiency and freedom from lubrication troubles in the field, the tractor manufacturer must first ascertain the oils suitable for his engine; second, recommend a sufficient number of them to cover all territories, insisting on their use; and third, help to educate tractor owners to the importance of correct lubricating oil and its proper care. This need cause no discrimination as regards oil refiners because it is possible to find several oils from various sources which are equally suitable for any particular engine.

In conclusion I repeat that I believe the field of lubrication offers fully as great an opportunity for research and development as any other in tractor work, and that such research and development must be carried out in conjunction with carburetion, ignition and engine design.

THE DISCUSSION

C. P. Fortner:—The following contains a few statistics in regard to the oil situation at the present time:

"In 1916 all the oil fields in the United States produced 312,000,000 barrels of crude oil. In that year the demand exceeded the production. In 1917 the entire production was 341,000,000 barrels. This was all consumed and the reserve stock was drawn on for 50,000,000 barrels. In the past two months, on account of the extremely cold weather, drilling for new production has been practically suspended. In one field alone there were 115 drilling rigs set for drilling, of which 80 did not turn a wheel. This means new production has already been reduced nearly 16 2/3 per cent. It will be impossible to overcome this shortage. It is safe to say these same conditions existed throughout Kansas and Oklahoma. As we used 50,000,000 barrels from the reserve stock in 1917, probably with the increased demand on account of the increase in the automobile and tractor business, and also in the steamships now building and to be built, nearly all of which are oil burners, the demand for this year will double the amount drawn from the reserve stock, or 100,000,000 barrels."

However, for this year at least there will be enough fuel in the market for tractor consumption; I cannot say anything about the price, but I can state that there probably will be enough fuel.

The method of distribution is very important. The company that I represent is a very large distributer of fuel all over the United States—all over the world at one time—and during the past three years we have been establishing stations, until at this time we average a station every 20 miles on the railroad lines throughout the country, with the exception of the State of Texas. Further than that, we are rendering a valuable service to the farmer by giving him the benefit of this service. From a study of maps we have worked out rural routes, and at nearly all of our stations, as fast as is possible, the agent is being equipped with a tank wagon—a motor truck wagon, in fact—in order to make deliveries direct to the farmer. At the present time the farmer is considered a plant. The farmer has a stationary engine, an automobile, and possibly a tractor, and he is entitled to the service which we have worked out for his benefit. I think this will be appreciated by the tractor builders, as it helps them to sell their product throughout the country. The farmer will get his fuel and his lubricants right at his door.

J. V. Mahoney:—Several years ago, with the old splash-tank type of tractors, practically all the trouble experienced was due to ignorance on the part of the operator. In one case a tractor was delivered with an engine having a non-circulating splash system. The engine was of the four-cylinder vertical type, the crankcase having one compartment in which the oil was permitted to slop from one end to the other. When the machine was traveling up hill all the oil went into the rear cylinder and when going down hill it was all in the front. On a hilly field the farmer spent about 90 per cent of his time cleaning the front or the rear spark-plugs. The farmer asked the expert who delivered the tractor how often he would have to put oil in the crankcase. "Well," the expert said, "not the first year, and only once the second year." This was out in Glasgow, Mont., and I believe the farmer's repair bill in about two weeks amounted to $780 and my time.

R. E. Plimpton (M. S. A. E.):—As Mr. Clark mentioned a couple of months ago (February issue), an article appeared in The Journal on specifications for lubricating oil. Four or five years ago the Society had something of the same problem in connection with steel. The Standards Committee got the steel makers and the automobile engineers and others interested in using steel to work together, until finally S. A. E. steel specifications

were formulated. It is believed we can formulate specifications for lubricating oil. The suggestions in Mr. Stratford's paper appear reasonable, and they are complete and definite. I would like to ask Mr. Clark whether, if the oil refiners and the tractor engineers and others actually using the oils will cooperate, we cannot get some lubricating oil specifications that will be of benefit to everybody, so we can get the right quality of oil and get it at a fair price.

MR. CLARK:—I mentioned that article for the reason that Mr. Plimpton brought out and in the hope that some of the members had read and discussed the article and would give opinions on it. The procedure outlined in that paper appeals to me as a possible means of doing away with the tests used in the past for determining oil suitability. It seems logical, and in my opinion it is all right, although it is new and has not been tried out thoroughly.

MR. FORTNER:—As regards lubricating oil, it seems to me that if the engine requirements continue to increase the oil men will be backed up against the fence. Oil is not phenomenal, and has its limitations. On this proposition the oil men would like to ask for the cooperation of the engine designers. Lubrication troubles that we are having might be due to faulty engine construction. It is a fact that fuels are necessarily heavier, that the requirements are greater, and that we are contending with something that causes the rapid dissolution of oil where it comes in contact with it. Under certain conditions, after the oil has rested, it will regain its viscosity but ordinarily the extreme heat and contact with the fuel thins the lubricant rapidly.

H. C. BUFFINGTON (M. S. A. E.):—Perhaps some of the oil men could tell us how to design our engines.

MR. FORTNER:—Two oils from different fields, subjected to the same physical tests in the same engine under the same conditions, may give altogether different results.

A standard lubricant therefore cannot be manufactured unless the base from which the lubricant is taken is known. That is something absolute—that we know and can all agree on. We should know the base of the crude in order to arrive at the correct base for the lubricant for tractor or automobile engines of any description.

P. J. DASEY:—While our experimental laboratory has been only partly installed and in use less than a month, experiments have been carried out with fuels and lubricating oils which indicate to a certain degree the end in engine design to which we must work if more successful operation and service to the customer are to be reached.

Gasoline as Fuel

Gasoline varies in nature as much as the men who make it. Some refiners make gasoline with a fairly low initial boiling point and a low end point in the distillation range; this is called good or high-test gasoline. Others make a product of heavy material blended with casinghead gasoline, the latter a very light product, in order to make starting easy; in many cases the heavy material is not suitable for use in gasoline engines and condensation results, with loss of fuel and dilution of lubricant.

Other refiners make a product consisting entirely of heavy material which is not easy to start on and also brings about loss of fuel and dilution of lubricant.

The first kind, high test, is really the only gasoline fit to use in an engine not provided with means for heating the gasoline in order to turn it into gas. Its use insures that condensation will not take place and that the lubricant will do its work as intended, assuming that the lubricant is of the proper quality for the particular type of engine being used.

It is safe to say that in the majority of cases it is better to use some kind of heating device in order to assist gasification of the heavy ends of the fuel even though a slight loss in volumetric efficiency is noted; the reasons are that greater economy is obtained and danger of bearing trouble is reduced owing to the absence of lubricant dilution and there being no necessity for changing it as often as would otherwise be required.

Kerosene As Fuel

Kerosene is heavier than gasoline, and, pound for pound, gives more heat units than gasoline, but it is far more difficult to use. It also varies in composition somewhat the same as gasoline, although to a less degree, for the reason that laws have been passed to keep refiners within certain limits as to the light end content, while the necessity for having an oil that will not smoke when used in lamps caused the refiner to keep the heavy ends as well within certain limits, giving the user an oil well cleaned and practically water white in color.

The average engine of today will not handle kerosene as efficiently as gasoline because of the inherent qualities of these fuels, which are so little understood.

The end points of different grades of gasoline should not be above the temperatures noted below:

High test gasoline, deg. fahr.	300
Good gasoline, deg. fahr.	410
Common gasoline, deg. fahr.	430
Poor gasoline, deg. fahr.	450

Average gasolines have end points between 410 and 430 deg. fahr.

Kerosene varies from 475 to 500 deg. fahr. end points and has an initial boiling point of from 265 to 300 deg. fahr.

From this it will be seen that a gasoline ranging in distillation temperature from 120 to 410 deg. fahr. has considerable kerosene content—say all of that part of it distilling over between 300 and 410 deg. fahr., which will average around 40 to 50 per cent.

On the other hand, kerosene can be said to contain a considerable proportion of gasoline, if one chooses to look at it that way, as all of it distilling over below 410 deg. can be classed as gasoline.

Personally, in my research work, I take kerosene as I find it and call it kerosene, and likewise I consider as unadulterated gasoline only that portion of commercial gasoline which distills over below the point where kerosene begins; for laboratory purposes I have set that point at 300 deg. fahr.

In the tractor field as in the automobile field we are forced to take gasoline as we find it for sale on the market. It is safe to say that about a half-and-half mixture is being sold, although the kerosene half is the lightest end of the kerosene, and is handled more easily than would be a mixture of 50 per cent high test gasoline and 50 per cent kerosene for the reason that the former does not contain the heavy material which causes so much trouble.

Splash Feed Lubrication

The lubricant used in splash feed engines must be fluid enough, even when cold, to be readily distributed, yet have sufficient body when hot to keep the wearing surfaces apart under maximum load working conditions. The oil is forced to the bearings solely by gravity, and, under such conditions, it must be very thin to work in

between the surfaces. When it is considered that the load on the bearings of a tractor engine is practically maximum at all times, it is remarkable that any great service is obtainable from such as are splash fed, but we know that they do give good service in many instances.

With the oil in a thinned-out condition from heating and then cut or diluted with kerosene, the condition is far worse and damage more likely to result than in an engine using gasoline, because the body of the oil is reduced in resistance and must naturally allow metal-to-metal contact at a much earlier load stage than when the oil is undiluted.

If to this condition of reduced efficiency of the oil is added that of fine particles of silicon or sand being taken into the cylinders and washed down into the crankcase, also the grit which gets in through the breather tube, we will have a condition that is really serious. The sand is bad enough in new oil but its cutting action does not get into full stride until the oil has become diluted. The greater the dilution the greater the cutting effect will be, hence the vital importance of keeping out the fine silicon particles and preventing dilution of lubricant.

Pressure Feed Lubrication

In heavy-duty work pressure feed to all wearing parts is of first importance. In the first place, it permits the use of a heavier-bodied oil, because the oil is moved by pressure to the necessary points. The heavier oil will stand up under heavier working pressures without breaking down. The oil feed increases as the speed increases, and in case of dilution the heavy oil can stand more than the thinner oil without reaching the danger point.

Dust or silicon is not as effective in heavy oil as in light, thin oil. I do not mean to say that dust-laden oil is not to be considered as a poor lubricant in the case of the pressure-fed engine. On the contrary, I am convinced that the first tractor engine requirement is to completely eliminate the possibility of dust or sand getting into it, and unless this is done efficiently some other prime mover will make its appearance in the near future and eventually displace the internal combustion engine in the tractor field. I feel sure, however, that in this great industry there are brains sufficient to solve this matter in short order, once its importance is realized. In fact it is well on the way to solution at the present time.

Governor Control of Engines

While governors might not seem to have anything to do with lubrication, upon close analysis the two subjects are found to be intimately connected.

There are two sources of heat in an engine, the burning of the charge in the cylinder and friction. All oils have limits of temperature beyond which it is not safe to subject them, if best results are to be obtained. Let us assume that an oil is working well in a four-stroke cycle engine, wide-open throttle, running at 1000 r.p.m. (500 explosions per minute), and consider the explosive and frictional heat generated at that speed. Any increase in engine speed, with load, will necessarily result in considerably more heat from the burning charges, giving a larger percentage of frictional heat because the frictional load increases much more rapidly above 1000 r.p.m. than it does below that point; especially is this true if radiation has been figured on the basis of 1000 r.p.m., maximum working load. Therefore, to my mind it is of vital importance to regulate or govern positively the engine speed not to exceed 1000 r.p.m., and provide the necessary factor of safety in radiation.

I have recently made some tests on oil, the results of which, as noted below, are accurate within a fraction of one per cent.

New Oil Test

The contents of a well-known lubricating oil were as follows:

Material distilling up to end point of kerosene distillation, per cent	10.50
Lubricating distillate, per cent	86.75
Coke, per cent	2.75
Total, per cent	100.00

Test of Oil Used with Gasoline

The same oil, used with high test gasoline fuel for 20 hours, under full load at 1000 r.p.m., was of the following composition:

Material distilling up to end point of kerosene distillation, per cent	0.00
Lubricating distillate, per cent	95.50
Coke, per cent	4.50
Total, per cent	100.00

This shows that at the end of 20 hours' run, all of the light material had disappeared and the coke had increased from 2.75 to 4.50 per cent, that is 1.75 per cent.

The test was run with high-grade gasoline to prevent dilution, and it shows not only no dilution, but that the light ends of the lubricating oil itself are missing, being used up as fuel.

Test of Oil Used with Kerosene

The next test was with a similar new oil, after it had been used for one week, under full load conditions, with kerosene for fuel.

Material distilling over up to end point of kerosene distillation, per cent	40.50
Lubricating distillate, very light, per cent	55.00
Run down to coke, per cent	4.50
Total, per cent	100.00

This test shows 40.5 per cent dilution, a net gain of 30 per cent above what the new oil contained in light material, and does not take into consideration any part of that light end that undoubtedly was consumed, as in the first test mentioned. It does show 40.5 per cent light material, which is really a fuel, 55 per cent of a lubricating distillate too light for any purpose except high-speed spindle work and an increase in the coke (carbon).

The separation of the carbon in the form of coke removes the large percentage of real lubricant or body of the oil.

It will be noted that in the oil used one week the coke content is larger than in the unused oil, where it is but 2.75 per cent. This increase is undoubtedly due to a partial breaking down or decomposition of the lighter portions, the light gases being burned and the heavier ends containing the tar carried or washed down into the crankcase.

Later, a series of tests will be made with different oils to determine how long it is advisable to allow an engine to operate with the same oil, using gasoline and kerosene as fuels. These determinations appear to be very important owing to the fact that a certain percentage of dilution must be figured on in all kerosene-burning engines, especially those of the vertical type, until the use of kerosene fuel has reached a more developed stage. Undoubtedly some engines operate with less dilu-

tion than others, but so far I have not received a single sample of oil that does not show dilution. These have been from all types and sizes of engines.

The first thing to consider in the solution of the tractor engine lubrication problem is to strain the air entering the carbureter and breather tube so that it will be as nearly 100 per cent clean as possible. That will eliminate the cause of a large part of the lubrication problem. The next question is to govern properly the engine speed; pressure oil feed to all wearing surfaces should be employed; the tractor manufacturer should use and insist on customers using the best lubricating oil obtainable, and to change it as frequently as is determined necessary by positive test. If fuel-oil engines are developed to a higher point of efficiency to avoid dilution only minor difficulties will remain.

At a recent meeting of the Agricultural Engineers Society it was stated in a paper read by a professor of engineering of a large Western agricultural college that an analysis of the "carbon" taken from the cylinders of engines in use in the field showed:

10 per cent which would dissolve in gasoline.
10 per cent which would dissolve in chloroform.
80 per cent silicon.

That should be kept in mind.

(Discussion contributed after adjournment)

EDW. A. LA SCHUM (A. S. A. E.):—Lubrication, or, rather, lack of lubrication, we believe is one of the things that caused us much trouble and expense in operating the motor vehicle equipment of the American Express Company. This condition has developed more especially since it became necessary for us to use the heavier fuels. We were seriously troubled with oil dilution owing to gasoline working past the pistons into the crankcase, and, of course, this was more pronounced during the winter months. We were buying cylinder oil from various refiners or jobbers, believing that we were getting the best oil produced, but after much trouble with burnt-out connecting-rod bearings, scored cylinders and pistons, lack of power, difficult starting, waste of fuel, etc., we decided to do a little research work, and therefore purchased some laboratory apparatus, consisting of a standard Saybolt viscosimeter, also apparatus for flash and fire tests, and the necessary apparatus for making the cold test. We commenced making tests of various brands of cylinder oil in the early part of the winter of 1917.

A little practice soon convinced us that gravity and color were of no importance to us; that flash and fire figures were of comparatively little importance, but that viscosity was of great importance; of course, we had to provide oil that would pour at the temperatures of winter. We started out with the idea that the oil we were using was not heavy enough for the purpose. We believed that by using the heavy oil we could practically dam the flow of gasoline past the piston and bring about higher compression, more perfect combustion, cleaner valves and hence greater power, all of which goes a long way in bringing about economy of fuel and the elimination of troublesome repairs caused by dilution of oil in the crankcase.

By experiment and observation we have reached the conclusion that an oil suitable for our purpose should be about as follows:

Gravity, deg. Baumé	19.3
Flash open cup, deg. fahr., about	370
Burn, deg. fahr., about	400
Chill at, deg. fahr	0
Viscosity at 100 deg. fahr., sec	470
Viscosity at 212 deg. fahr., sec	56

We are now using oil which meets these specifications and the result has been most gratifying. Burnt-out bearings are a thing of the past; oil dilution does not trouble us; engines are more easily started and drivers report much more snap, which is a very satisfactory condition all around.

I agree with Mr. Clark that the selection of proper lubricating oil offers a big opportunity for more extensive experimental work than has been done in the past, because lack of information on this subject and the neglect of oil refiners to lend assistance, has been responsible for many lubrication troubles. The selection of oil should be determined, to a great extent, by the type of engine and service required, but I have found no difficulty in using the same grade of oil on the several types of engines operated by the American Express Company. We have a number of sleeve-valve engines and a great number of poppet-valve engines, also high-speed and low-speed engines. We use the same grade of oil in all types, even in the horizontal engine.

We believe that the performance of oil in an engine can be fairly accurately predicted by the physical test as given in the ordinary oil specifications, and that the consumer who operates a large number of motor trucks should make frequent laboratory tests of samples taken from regular stock deliveries to make sure that he is getting the oil specified.

I agree with Mr. Clark that putting fresh, clean oil in a dirty crankcase with wornout oil is a waste of good oil, and I am satisfied that many operators rely too much on the oil level gage. Spark-plugs will not foul if carburetion is correct and lubricating oil is properly selected and kept clean. I feel sure that maintenance costs can be materially reduced by carefully working out the lubrication problem. I have found it simple and easy to do, and believe that every operator of motor trucks should give the matter immediate attention.

Hydraulic Power Transmission

By F. McDonough* (*Non-Member*)

Minneapolis Section Paper *Illustrated with* Photographs and Charts

IN beginning any investigation of the subject of transmission as applied to gas-engine driven vehicles, the feature impressing itself most forcibly upon the mind of the investigator is the fact that the speed control of the vehicle through its entire range is indirect and secondary. The prime mover, the engine, can be run, if desired, by means of a governor at a stated speed, but the control of the car by means of the clutch and of the different gear trains is entirely apart and distinct from the operation of the engine, that is, from zero speed to maximum. The principle of the present system, used generally upon automobiles and trucks, of throwing sliding gears of different ratios into mesh while they are revolving, is somewhat weak, and if it were not for the finest materials, workmanship, and detailed engineering design, the result, as far as this part of the vehicle is concerned, would long ago have been a failure.

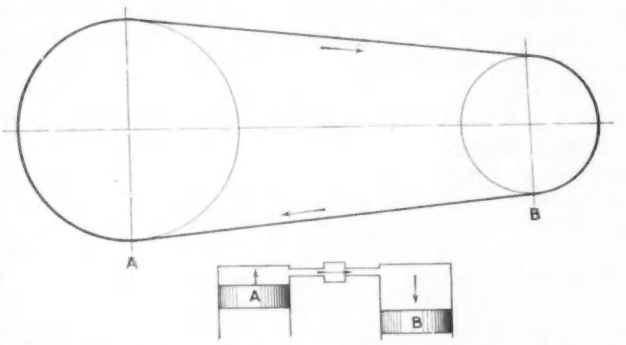


Fig. 1—Illustrating the Analogy between Belt and Hydraulic Transmission of Power

At one stage of the development of the automobile the difficulties experienced with the operation of the sliding-gear device resulted in the use of the variable disk friction drive, with its numerous but small variations of speed. For a time at least this found considerable favor because it had the required flexibility—but, on the other hand, because of slippage, loss of efficiency and lack of positiveness, its use on automobiles was generally discontinued, although it is now used in some forms of gas tractors.

If the uniform and unlimited graduations of speed of the disk friction drive could be combined with the positiveness of the gear drive, and at the same time if the effective pull or torque of the driven member could be increased directly as the speed was reduced, with a perfect flexibility of forward and reverse speeds, the long-looked-for efficient and flexible transmission for motor-driven vehicles would be at hand.

Such a development seems to have arrived in a hydraulic transmission. That such represents the most advanced thought in the engineering world is evidenced by an editorial appearing in the *American Machinist*, of June 17, 1915, which, after a statement as to the need for an ideal speed transmission and after a discussion of the gear, electric, and hydraulic transmissions, states in effect that unquestionably the development of the future for efficient variable speed mechanisms will be of the hydraulic type. This is further evidenced by the amount of designing and number of patents obtained by some of the greatest engineers both here and abroad, in the hydraulic transmission field, illustrations of some of which will be shown later.

The term hydraulic is an unfortunate one ever to have been applied to this form of transmission. "Hydraumotive," or some such coined word, would have described it and have differentiated it better from the ordinary hydraulic machinery, which includes a great variety of mechanical appliances, such as all forms of water wheels, water pumps and systems, hydraulic rams, presses, and accumulators, most of which derive their power from static force.

In the form of transmission under discussion the liquid or fluid, generally oil, forms only the means of transmitting power from the driver to the driven member, it being under no particular strain when there is no resistance for the driven member and performing exactly the same functions as the ordinary belt, chain, or rope, in the pulley and belt arrangement shown in Fig. 1. When one set of pump or pressure-engine pistons, *A*, is driving another set of pump pistons, *B*, the function of the oil is exactly the same as that above in the belt. The oil on the slack side of the hydraulic motor is returned to the driving side and the circulation is established exactly as in the case of the belt drive. If the oil, under extreme speed and load of the driven member, has but little pressure and plenty of room to circulate in, the frictional resistance of the oil upon oil—or upon itself—can be only of a slight amount. If the conditions stated in regard to the speed and the pressure of the transmitting fluid apply, the efficiency must be uniformly high. At the bottom of Fig. 2 is also shown a diagram of the forces from cylinder *A* reacting upon cylinder *B*, showing that with a drive of this kind the pulling power of the driven member increases directly as its speed decreases and the relation of the fulcrums change. The speed and the leverage of the driven member is controlled by the amount of oil, which is passed from the driving to the driven side when the driving side is rotating at a fixed number of revolutions. The number of cylinders in both hydraulic motors is always made an odd number so that there are no dead centers and the dis-

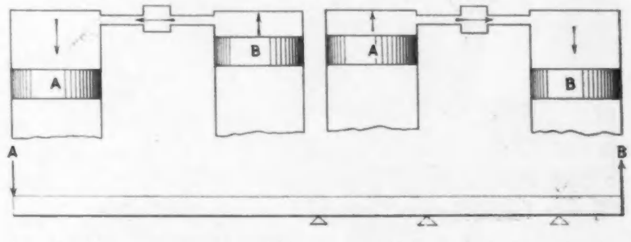


Fig. 2—Principle of the Hydraulic Transmission, Showing Action of Forces

*Engineer, Toro Motor Company.

charge impulses overlap, giving a practically uniform amount of flow for any capacities of circuit.

Fig. 3 shows one form of hydraulic motor, pressure engine, or pump, with five cylinders, the pistons being reciprocated because the connecting-rod crankpin is thrown out of center. This can be varied to a greater or

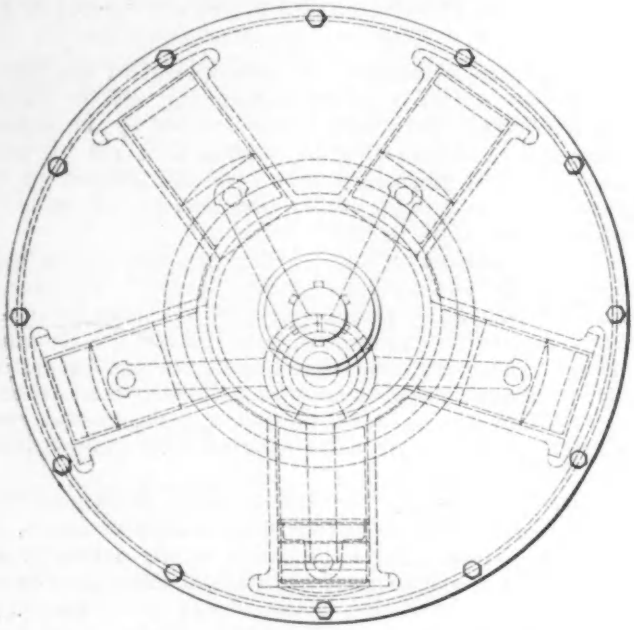


FIG. 3—FIVE-CYLINDER HYDRAULIC MOTOR OR PUMP

less degree, giving a greater or less movement to the pistons and increasing or diminishing the flow of oil from cylinders *A* to cylinders *B*. The pistons to the right of the vertical center of the motor are pushing oil out and correspond to cylinders *A* in Fig. 1 and those to the left are pulling in the oil on the slack side from the cylinders *B*. In a transmission of this kind there are two hydraulic motors exactly alike, one being the driver and the other

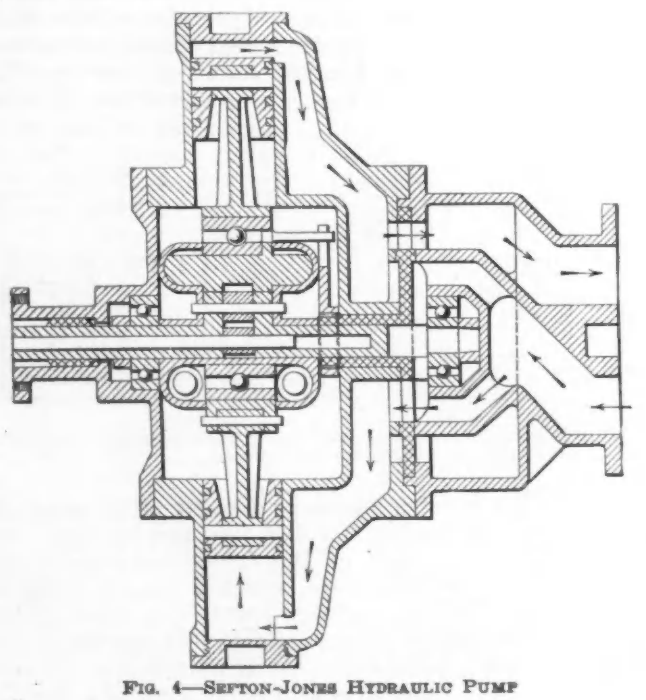


FIG. 4—SEFTON-JONES HYDRAULIC PUMP

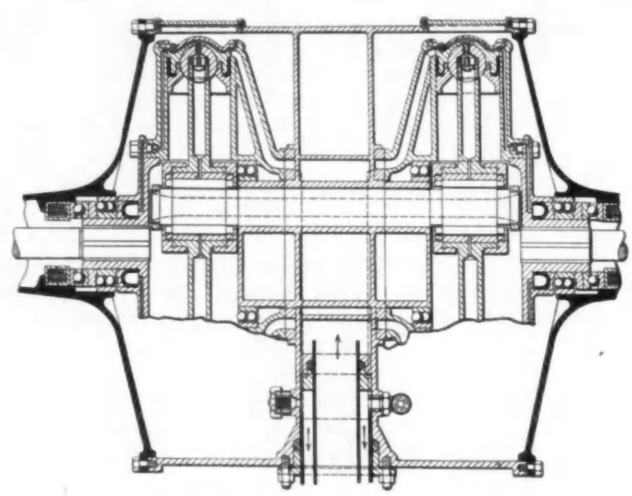


FIG. 5—CONRADSON REVOLVING PUMP

being driven. The reversing motion in this appliance is accomplished the same as in the ordinary reversing steam engine, the driving and driven sides of the pistons being interchanged by moving the crankpin from one side of the center to the other at the will of the operator.

Fig. 4 is a form of hydraulic mechanism made by an English inventor, Sefton-Jones, which relies to some extent upon the action of throttling or throwing-in resistance to decrease some of the speeds and so is open to the same objection, as far as efficiency is concerned, as are some of the electric form of drives.

Fig. 5 is a form of the Conradson revolving pump with stationary valve face and reaction cylinders to keep the rotating pump oil-tight against the stationary valve face. This reaction device is also used in the hydraulic motors designed by the French inventor Barbarou. The Con-

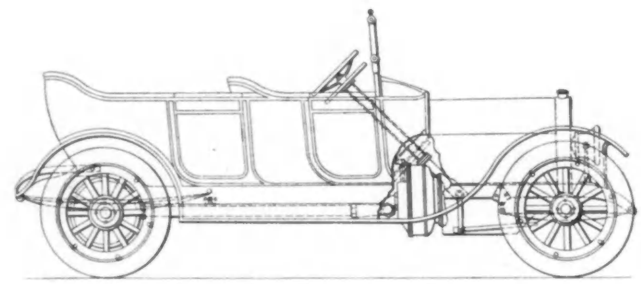


FIG. 6—LOCATION ON CAR OF DEVICE SHOWN IN FIG. 5

radson device has two hydraulic motors on the rear axle and one directly attached to the engine (see Fig. 6).

Fig. 7 represents a form of hydraulic transmission used by Delauney-Belleville of France. The cylinders are placed horizontally in rotating barrels, which are about the same general form and shape as the barrels in a revolver. The pistons obtain their movement from a flat plate that rocks transversely to the driving shaft, the angle of which is controlled by the operator by means not shown in the figure. This form of transmission, Fig. 8, is used in the Pratt "auto-gear" and by the Waterbury Tool Company; also in revolving turrets on battleships, where a heavy pull at low speeds is required.

The author, having had some experience in the hydraulic transmission field, was called upon with other engineers to investigate the merits of the hydraulic transmission patented by Joseph Rosche. This device, Fig. 10,

embodies a simple and practical realization of the hydraulic transmission as applied to motor vehicles. In this transmission the driving and driven cylinder pistons are stationary when both are rotating at the same speed, so that as applied to automobiles or trucks there is no movement of the oil or of the pistons when the machine is on high, or direct connection. In the uses cited above such a condition obtains the greater part of the time when in operation, so that the efficiency of such an appliance would be high. This appliance also possesses the valuable features of having no revolving surfaces coming in contact (thus requiring that the joints be maintained perfectly) as the driver and driven sets of cylinders are in one casting. All overhanging support bearings are eliminated, the strain being brought down directly between shaft journals of any size, strength, and power desired. The working hydraulic fluid is kept entirely on top and directly between the driving and driven pistons, no pipe joints of any kind being used. The mechanism is a completely constrained one both mechanically and hydraulically through all of its phases of unlimited speed variations in both directions. Taking it in every way, an advanced step in the simplification of the hydraulic transmission problem has been attained by this device.

THE DISCUSSION

A MEMBER:—How is the efficiency of this transmission increased over that of an ordinary gear transmission in high?

MR. MCDONOUGH:—There are no gears. In an automobile the transmission is locked in a mechanical clutch and in this device it is locked with a hydraulic clutch. When

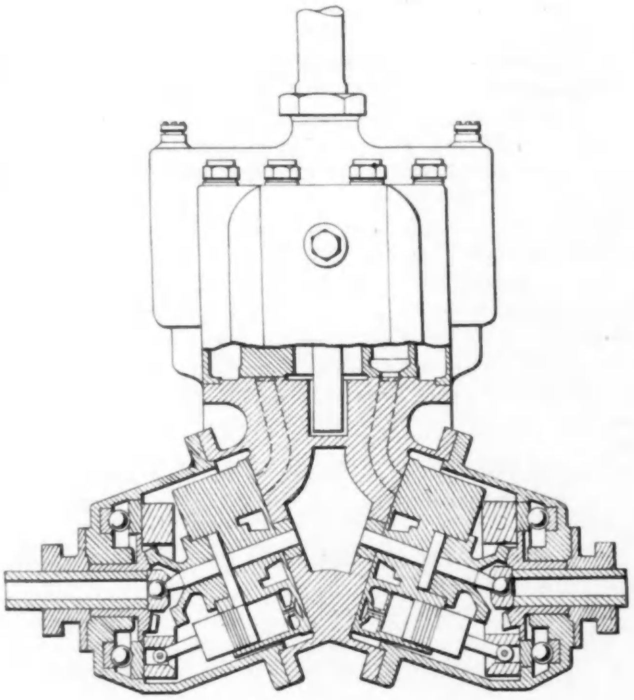


FIG. 7—DELAUNEY-BELLEVILLE HYDRAULIC TRANSMISSION

we have two bodies locked we cannot increase the efficiency of transmission. Oil is as incompressible as steel, or more so, and there is hardly anything with less friction than oil.

H. C. BUFFINGTON (M. S. A. E.):—What is the efficiency?

Efficiency of Manly Transmission

MR. MCDONOUGH:—Another form of hydraulic transmission, the Manly, which is not as efficient as the Rosche transmission, gave an efficiency of 91.9 per cent at 270 r.p.m., according to a test made by George H. Barrus.*

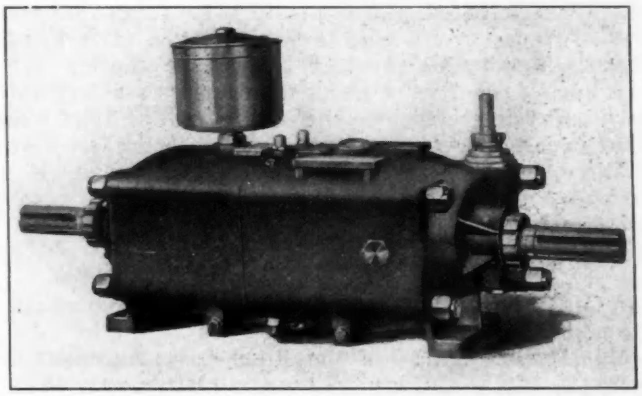


FIG. 8—EXTERIOR OF WATERBURY HYDRAULIC SPEED GEAR

At 350 r.p.m. of the driven member, and, as I remember it, 950 r.p.m. of the driver, the efficiency was 87.4 per cent, and at 163 r.p.m. of the driven member was 89 per

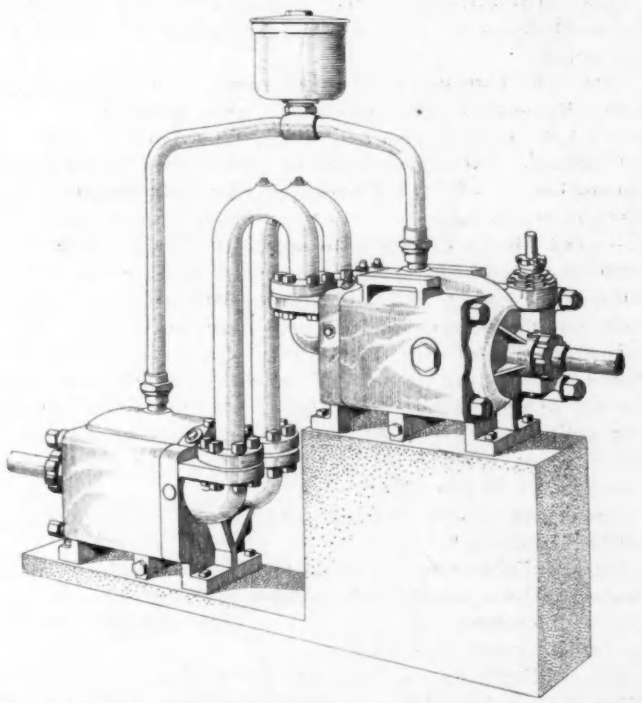


FIG. 9—LOCATION OF AIR PLUGS AND OIL EXPANSION BOX CONNECTIONS FOR THE DEVICE SHOWN IN FIG. 8

cent. The Waterbury transmission has an efficiency of about 80 to 90 per cent.

Construction of Waterbury Transmission

CHAIRMAN E. R. GREER (M. S. A. E.):—The Waterbury transmission is a hydraulic reducing gear, is it not? Is the flow of oil in it small in all cases?

MR. MCDONOUGH:—The driving shaft of the smallest Waterbury gear runs at 1000 r.p.m. They range from there down to 500 or 400 r.p.m.

MR. BUFFINGTON:—Is there any trouble from leakage

*Transactions of the American Society of Mechanical Engineers, 1911, page 851.

of oil that might hinder the operation of the transmission?

MR. MCDONOUGH:—Provision has to be made for that. In the view of the Waterbury transmission may be seen the supply tank of oil in which there is a weighted piston something like an accumulator, and all of the interior, the working part, of this hydraulic device is filled with oil. The weighted piston provides an opportunity for the oil to occupy its space and relieve the valve in case there is any undue pressure brought on the oil.

A spring relief valve about the same as a safety valve on a boiler is provided so the oil can relieve itself somewhat in case the pressure should exceed certain set limits. If there should be any undue pressure this valve will go up and in case there is leakage continuously the valve goes down so a supply is kept on hand.

Construction of Rosche Transmission

A MEMBER:—What parts of the Rosche transmission are stationary and which rotate?

MR. MCDONOUGH:—In the Rosche transmission, the crankpin of the driving cylinder is stationary.

A MEMBER:—That is the only essential part that is stationary?

MR. MCDONOUGH:—That is the only part that is stationary. The cylinders revolve, and, of course, the pistons reciprocate within the cylinder walls.

MR. BUFFINGTON:—Do I understand that the Rosche transmission does away with the flywheel, the clutch and the gears?

MR. MCDONOUGH:—It does away with sliding gears and ultimately with the other parts mentioned. It is not a hydraulic transmission that runs to the rear axle or wheels. Of course, some other forms of hydraulic transmissions like the Conradson have endeavored to cut out gears altogether. The Conradson device, shown on the rear wheels of the automobile in Fig. 6, does away with the flywheel, clutch and the sliding bevel and differential gears. The Rosche transmission overcomes some complications, such as revolving valve faces in the Delauney, Waterbury, Conradson, etc., and pipe joints. There are no pipe joints and the driven and driver parts are all in one casing. The oil is on top of the pistons. The cylinder is single-acting and there are no curves or convolutions for the oil to pass through in going from one cylinder to the other.

CHAIRMAN GREER:—What are the chief difficulties with the Manly drive?

MR. MCDONOUGH:—I do not know, except that it seemed to be a heavy and complex mechanism.

G. C. ANDREWS (M. S. A. E.):—They had trouble with the fluid, too; it lost its life.

MR. MCDONOUGH:—I did not hear of it; there would be no reason for that. I have seen three of the Manly trucks running in New York City; I watched one in operation which had run for two years and the life of the oil could be made to stand ordinary pressures for an indefinite length of time.

KIND OF OIL USED

MR. BUFFINGTON:—Is a special kind of oil required?

MR. MCDONOUGH:—A good clean mineral oil, without any acid or alkaline reaction.

MR. BUFFINGTON:—Would it have to be thin, medium or heavy?

MR. MCDONOUGH:—It ought to be an oil that would not lose any of its properties when traveling at considerable speed.

MR. BUFFINGTON:—Would there be any bad effects from heavier oil in cold weather?

MR. MCDONOUGH:—That would all depend upon the kind of oil used. There would be no bad effects with a proper oil.

MR. BUFFINGTON:—Does not almost any oil become stiff in cold weather?

MR. MCDONOUGH:—Yes, an oil that would stand cold weather is required. Cranes worked hydraulically with oil have operated for over 60 or 70 years in London and Paris, in all kinds of weather. This hydraulic proposition is not new. In practically every shipyard they are using hydraulic presses, forges and punches, in which the pressure runs up to 4000 lb. per sq. in., with the joints tight, where leakage would be fatal.

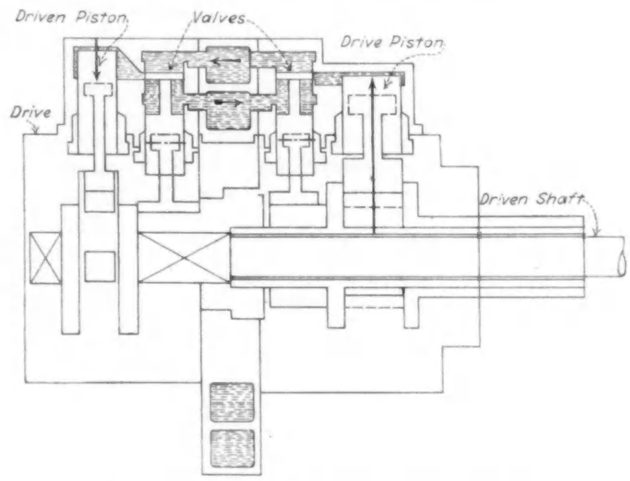


FIG. 10—ROSCHE HYDRAULIC TRANSMISSION

A MEMBER:—Is a hydraulic transmission on an automobile easily limbered up in cold weather?

MR. MCDONOUGH:—One-quarter of a spin will limber it up. In February on one of the coldest days I recall there was no trouble at all of that kind on trucks I was watching in New York.

A MEMBER:—Of course, in New York the temperatures do not get very low.

MR. MCDONOUGH:—Mr. Rosche had a transmission of this kind installed in a car and he operated it at 20 deg. below zero. There would not be any more trouble from that cause than from water freezing in the radiator. We remember what was said about that in the earlier days of the automobile before we started to put in alcohol.

A MEMBER:—Is the oil likely to foam or to break up?

MR. MCDONOUGH:—Not if the oil is of a proper consistency.

A MEMBER:—The chambers are entirely filled with it and there is no air?

MR. MCDONOUGH:—There is no air. It must be full of oil.

A MEMBER:—How would a little air in the system affect it?

MR. MCDONOUGH:—It would not affect the system at all beyond making the machine jerky. I have been connected with Mr. Conradson in making a hydraulic shaper and we found out that the air must be kept out of the cylinder. It is just like filling a barrel. It cannot be filled without getting the air out.

A MEMBER:—What is the weight of the device?

Hydraulic Transmission Weight

MR. MCDONOUGH:—In comparison with first-class gear transmissions, I should say that the weight would be about the same. It would not be very much greater than the weight of the flywheel. On the Conradson machine I know we designed it so it would be practically the same as the flywheel weight.

A MEMBER:—Does the casing revolve with the same speed as the driven part or the driver?

MR. MCDONOUGH:—The casing must always revolve with the driver. Both cylinders and all the mechanism and the casing revolve at the same speed as the driver, but the driving pistons are connected to the engine and the driven pistons are connected to the rear axle through a differential motion, set up between the driver and the driven member through the action of the oil.

A MEMBER:—Does the entire transmission revolve all the time the engine is running?

MR. MCDONOUGH:—Yes, if desired.

A MEMBER:—I mean that if the engine is running idle a flywheel is required; is it not?

No Flywheel Required

MR. MCDONOUGH:—The hydraulic transmission takes the place of the flywheel.

A MEMBER:—Then it runs continuously?

MR. MCDONOUGH:—Yes.

MR. BUFFINGTON:—The oil circulates fastest when the car is standing still and the engine is running idle?

MR. MCDONOUGH:—The oil runs fastest when the car is in reverse. There is no circulation of the oil at all when the car is in high. It is a continuously constrained mechanism, both mechanically and hydraulically, going from high to low through all steps and when it gets to low it goes through all the steps in the reverse direction, in about the same way as the old disk friction device.

MR. BUFFINGTON:—If the rear wheels were jacked up, would there be enough friction to turn the wheels over?

MR. MCDONOUGH:—I have never tried that, but believe that there would be unless the controller crank was exactly in the zero position. In the Rosche device, when the car is standing still the crankpin is moved so that the displacement of the driving cylinders nullifies the action of the driven cylinders. In other words, enough oil is sucked through to neutralize the motion on the driven shaft. We might say that it has a reverse action.

CHAIRMAN GREER:—The question was asked whether the wheels would turn if the car was jacked up and the engine was running. As a matter of fact, I believe if the engine was running and the car jacked up, the wheels would not turn. They would be practically locked if the transmission was set on the neutral point.

MR. MCDONOUGH:—Referring to Fig. 3, for so much eccentricity in every position that this crankpin is away from the center, if it is only a hundredth of an inch, there will be some motion of the pistons back and forth and some positive and negative action. If there is no movement there is no motion of these pistons, and there is no movement of the oil, and driver and driven members are locked.

MR. BUFFINGTON:—In other words, it changes the stroke?

MR. MCDONOUGH:—It changes the stroke.

A MEMBER:—Is that done on the resisting or the primary movement?

MR. MCDONOUGH:—In this device it has been done on the primary mover; an Englishman named Hall had a device that did it on the driven movement. That is not as good, perhaps, as movement on the driver.

A MEMBER:—According to that, there is a differential variation between the driver and the driven members?

MR. MCDONOUGH:—No, there is not; properly speaking there is no differential there. There is a different rotative movement between the driver and the driven members.

A MEMBER:—Could you apply that transmission where the driven was going faster than the driver?

MR. MCDONOUGH:—Yes.

A MEMBER:—How would it provide for the valve action necessary to be set up between the driver and the driven piston?

MR. MCDONOUGH:—That is as simple as in the case of Fig. 10. One of these machines is running with the driven faster than the driver, and the capacity of the driver cylinders exceeds that of the driven cylinders. It has been run for two or three months and it ran all week at the truck and automobile shows at St. Paul, Minneapolis and at Kansas City.

A MEMBER:—Does the eccentric of the crankpin move in a straight line or has it a curved path? Is it necessary to have a piston valve?

MR. MCDONOUGH:—Yes, but in the device of Fig. 3 and in the Conradson pump there are no valves.

MR. BUFFINGTON:—How many cylinders are there on the Rosche? Five on each side?

MR. MCDONOUGH:—Yes.

MR. BUFFINGTON:—When the car is standing still and the engine is stopped, is it true that the car cannot be moved, and the wheels cannot turn—that they are locked?

MR. MCDONOUGH:—If the piston is in the center they cannot be moved but the wheels can move the engine the same as the engine can move the wheels. We have to provide a by-pass for a case where the engine is not moved.

Provision for Coasting

H. C. BUFFINGTON:—How is coasting provided for?

MR. MCDONOUGH:—By a by-pass or by regulating the driving eccentric.

H. C. BUFFINGTON:—They could not be disengaged like releasing the clutch?

MR. MCDONOUGH:—No, except through a by-pass.

H. C. BUFFINGTON:—To get it in position, is it necessary to set the cranks of the driver to correspond to those of the driven cylinder or in a central position?

MR. MCDONOUGH:—The cranks are not set the same in this particular Rosche transmission. They would be in the Conradson transmission but not in the Rosche. The area of the driving cylinder being larger than the driven, of course, the crankpin is not set in the center for zero speed. It is necessary to make the driver cylinder larger, in order to reverse the driven cylinder. At the same time that gives a "super-high"; that was the reason for making the cylinder larger.

A MEMBER:—I should think the characteristics of this transmission would adapt it better for truck or tractor uses than for passenger cars.

MR. MCDONOUGH:—There is some question about that. We have to study these questions more or less.

A MEMBER:—A question of proportion or of design?

MR. MCDONOUGH:—Of design.

Aeronautical Nomenclature

FOR the information of those interested in aeronautics the following nomenclature has been prepared by the National Advisory Committee for Aeronautics, with a view to eliminating the duplication, erroneous use, and confusion of terms, and to define the principal terms which have come into use in aeronautics. In the preparation of this nomenclature only those terms have been defined which are peculiar to this subject.

AEROFOIL: A winglike structure, flat or curved, designed to obtain reaction upon its surface from the air through which it moves.

AEROPLANE: See Airplane.

AILERON: A movable auxiliary surface used to produce a rolling moment about the fore-and-aft axis.

AIRCRAFT: Any form of craft designed for the navigation of the air—airplanes, balloons, dirigibles, helicopters, kites, kite balloons, ornithopters, gliders, etc.

AIRPLANE: A form of aircraft heavier than air which has wing surfaces for support in the air, with stabilizing surfaces, rudders for steering, and power plant for propulsion through the air. This term is commonly used in a more restricted sense to refer to airplanes fitted with landing gear suited to operation from the land. If the landing gear is suited to operation from the water, the term "seaplane" is used. (See definition.)

Pusher.—A type of airplane with the propeller in the rear of the engine.

Tractor.—A type of airplane with the propeller in front of the engine.

AIR-SPEED METER: An instrument designed to measure the speed of an aircraft with reference to the air.

ALTIMETER: An aneroid mounted on an aircraft to indicate continuously its height above the surface of the earth.

ANEMOMETER: Any instrument for measuring the velocity of the wind.

ANGLE:

Of attack or *of incidence of an aerofoil.*—The acute angle between the direction of the relative wind and the chord of an aerofoil, i. e., the angle between the chord of an aerofoil and its motion relative to the air. (This definition may be extended to any body having an axis.)

Critical.—The angle of attack at which the lift-curve has its first maximum; sometimes referred to as the "burble point." (If the "lift curve" has more than one maximum, this refers to the first one.)

Gliding.—The angle the flight path makes with the horizontal when flying in still air under the influence of gravity alone, i. e., without power from the engine.

APPENDIX: The hose at the bottom of a balloon used for inflation. In the case of a spherical balloon it also serves for equalization of pressure.

ASPECT RATIO: The ratio of span to chord of an aerofoil.

AVIATOR: The operator or pilot of heavier-than-air craft. This term is applied regardless of the sex of the operator.

AXES OF AN AIRCRAFT: Three fixed lines of reference; usually centroidal and mutually rectangular.

The principal longitudinal axis in the plane of symmetry, usually parallel to the axis of the propeller, is called the fore and aft axis (or longitudinal axis); the axis perpendicular to this in the plane of symmetry is called the vertical axis; and the third axis, perpendicular to the other two, is called the transverse axis (or lateral axis). In mathematical discussions the first of these axes, drawn from front to rear, is called the X axis; the second, drawn upward, the Z axis; and the third, forming a "left-handed" system, the Y axis.

BALANCING FLAPS: See Aileron.

BALLONET: A small balloon within the interior of a balloon or dirigible for the purpose of controlling the ascent or descent, and for maintaining pressure on the outer envelope so as to prevent deformation. The ballonet is kept inflated with air at the required pressure, under the control of a blower and valves.

BALLOON: A form of aircraft comprising a gas bag and a basket. The support in the air results from the buoyancy of the air displaced by the gas bag, the form of which is maintained by the pressure of a contained gas lighter than air.

Barrage.—A small spherical captive balloon, raised as a protection against attacks by airplanes.

Captive.—A balloon restrained from free flight by means of a cable attaching it to the earth.

Kite.—An elongated form of captive balloon, fitted with tail appendages to keep it headed into the wind, and deriving increased lift due to its axis being inclined to the wind.

Pilot.—A small spherical balloon sent up to show the direction of the wind.

Sounding.—A small spherical balloon sent aloft, without passengers, but with registering meteorological instruments.

BALLOON BED: A mooring place on the ground for a captive balloon.

BALLOON CLOTH: The cloth, usually cotton, of which balloon fabrics are made.

BALLOON FABRIC: The finished material, usually rubberized, of which balloon envelopes are made.

BANK: To incline an airplane laterally—i. e., to roll it about the fore and aft axis. Right bank is to incline the airplane with the right wing down. Also used as a noun to describe the position of an airplane when its lateral axis is inclined to the horizontal.

BAROGRAPH: An instrument used to record variations in barometric pressure. In aeronautics the charts on which the records are made indicate altitudes directly instead of barometric pressures.

BASKET: The car suspended beneath a balloon, for passengers, ballast, etc.

BIPLANE: A form of airplane in which the main supporting surface is divided into two parts, one above the other.

BODY OF AN AIRPLANE: The structure which contains the power plant, fuel, passengers, etc.

This nomenclature comprises Report No. 15 of the National Advisory Committee for Aeronautics, Washington.

BONNET: The appliance, having the form of a parasol, which protects the valve of a spherical balloon against rain.

BRIDLE: The system of attachment of cable to a balloon, including lines to the suspension band.

BULLSEYES: Small rings of wood, metal, etc., forming part of balloon rigging, used for connection or adjustment of ropes.

BURBLE POINT: See Angle, critical.

CABANE: A pyramidal framework upon the wing of an airplane, to which stays, etc., are secured.

CAMBER: The convexity or rise of the curve of an aerofoil from its chord, usually expressed as the ratio of the maximum departure of the curve from the chord to the length of the chord. "Top camber" refers to the top surface of an aerofoil, and "bottom camber" to the bottom surface; "mean camber" is the mean of these two.

CAPACITY: See Load.

The cubic contents of a balloon.

CENTER: *Of pressure of an aerofoil.*—The point in the plane of the chords of an aerofoil, prolonged if necessary, through which at any given attitude the line of action of the resultant air force passes. (This definition may be extended to any body.)

CHORD:

Of an aerofoil section.—A right line tangent at the front and rear to the under curve of an aerofoil section.

Length.—The length of the chord is the length of the projection of the aerofoil section on the chord.

CLINOMETER: See Inclinometer.

CONCENTRATION RING: A hoop to which are attached the ropes suspending the basket.

CONTROLS: A general term applying to the means provided for operating the devices used to control speed, direction of flight, and attitude of an aircraft.

CONTROL COLUMN: The vertical lever by means of which certain of the principal controls are operated, usually those for pitching and rolling.

CROW'S FOOT: A system of diverging short ropes for distributing the pull of a single rope.

DECALAGE: The angle between the chords of the principal and the tail planes of a monoplane. The same term may be applied to the corresponding angle between the direction of the chord or chords of a biplane and the direction of a tail plane. (This angle is also sometimes known as the longitudinal V of the two planes.)

DIHEDRAL IN AN AIRPLANE: The angle included at the intersection of the imaginary surfaces containing the chords of the right and left wings (continued to the plane of symmetry if necessary). This angle is measured in a plane perpendicular to that intersection. The measure of the dihedral is taken as 90 deg. minus one-half of this angle as defined.

The dihedral of the upper wing may and frequently does differ from that of the lower wing in a biplane.

DIRIGIBLE: A form of balloon, the outer envelope of which is of elongated form, provided with a propelling system, car, rudders, and stabilizing surfaces.

Nonrigid.—A dirigible whose form is maintained by the pressure of the contained gas assisted by the car-suspension system.

Rigid.—A dirigible whose form is maintained by a rigid structure contained within the envelope.

Semirigid.—A dirigible whose form is maintained by means of a rigid keel and by gas pressure.

DIVING RUDDER: See Elevator.

DOPE: A general term applied to the material used in treating the cloth surface of airplane members and balloons to increase strength, produce tautness, and act as a filler to maintain air-tightness; it usually has a cellulose base.

DRAG: The component parallel to the relative wind of the total force on an aircraft due to the air through which it moves.

That part of the drag due to the wings is called "wing resistance" (formerly called "drift"); that due to the rest of the airplane is called "parasite resistance" (formerly called "head resistance").

DRIFT: See Drag. Also used as synonymous with "leeway," g. v.

DRIFT METER: An instrument for the measurement of the angular deviation of an aircraft from a set course, due to cross winds.

DRIP CLOTH: A curtain around the equator of a balloon, which prevents rain from dripping into the basket.

ELEVATOR: A hinged surface for controlling the longitudinal attitude of an aircraft; i. e., its rotation about the transverse axis.

EMPANNAGE: See Tail.

ENTERING EDGE: The foremost edge of an aerofoil or propeller blade.

ENVELOPE: The portion of the balloon or dirigible which contains the gas.

EQUATOR: The largest horizontal circle of a spherical balloon.

FINS: Small fixed aerofoils attached to different parts of aircraft, in order to promote stability; for example, tail fins, skid fins, etc. Fins are often adjustable. They may be either horizontal or vertical.

FLIGHT PATH: The path of the center of gravity of an aircraft with reference to the earth.

FLOAT: That portion of the landing gear of an aircraft which provides buoyancy when it is resting on the surface of the water.

FUSELAGE: See Body.

GAP: The shortest distance between the planes of the chords of the upper and lower wings of a biplane.

GAS BAG: See Envelope.

GLIDE: To fly without engine power.

GLIDER: A form of aircraft similar to an airplane, but without any power plant.

When utilized in variable winds it makes use of the soaring principles of flight and is sometimes called a soaring machine.

GORE: One of the segments of fabric composing the envelope.

GROUND CLOTH: Canvas placed on the ground to protect a balloon.

GUIDE ROPE: The long trailing rope attached to a spherical balloon or dirigible, to serve as a brake and as a variable ballast.

GUY: A rope, chain, wire, or rod attached to an object to guide or steady it, such as guys to wing, tail, or landing gear.

HANGAR: A shed for housing balloons or airplanes.

HELICOPTER: A form of aircraft whose support in the air is derived from the vertical thrust of propellers.

HORN: A short arm fastened to a movable part of an airplane, serving as a lever-arm, e. g., aileron-horn, rudder-horn, elevator-horn.

INCLINOMETER: An instrument for measuring the angle made by any axis of an aircraft with the horizontal, often called a clinometer.

INSPECTION WINDOW: A small transparent window in the envelope of a balloon or in the wing of an airplane to allow inspection of the interior.

KITE: A form of aircraft without other propelling means than the towline pull, whose support is derived from the force of the wind moving past its surface.

LANDING GEAR: The understructure of an aircraft designed to carry the load when resting on or running on the surface of the land or water.

LEADING EDGE: See Entering edge.

LEEWAY: The angular deviation from a set course over the earth, due to cross currents of wind, also called drift; hence, "drift meter."

LIFT: The component perpendicular to the relative wind, in a vertical plane, of the force on an aerofoil due to the air pressure caused by motion through the air.

LIFT BRACING: See Stay.

LOAD:

Dead.—The structure, power plant, and essential accessories of an aircraft.

Full.—The maximum weight which an aircraft can support in flight; the "gross weight."

Useful.—The excess of the full load over the dead-weight of the aircraft itself, i. e., over the weight of its structure, power plant, and essential accessories. (These last must be specified.)

LOADING: See Wing, loading.

LOBES: Bags at the stern of an elongated balloon designed to give it directional stability.

LONGERON: See Longitudinal.

LONGITUDINAL: A fore-and-aft member of the framing of an airplane body, or of the floats, usually continuous across a number of points of support.

MONOPLANE: A form of airplane whose main supporting surface is a single wing, extending equally on each side of the body.

MOORING BAND: The band of tape over the top of a balloon to which are attached the mooring ropes.

NACELLE: See Body. Limited to pushers.

NET: A rigging made of ropes and twine on spherical balloons, which supports the entire load carried.

ORNITHOPTER: A form of aircraft deriving its support and propelling force from flapping wings.

PANEL: The unit piece of fabric of which the envelope is made.

PARACHUTE: An apparatus, made like an umbrella, used to retard the descent of a falling body.

PATCH SYSTEM: A system of construction in which patches (or adhesive flaps) are used in place of the suspension band.

PERMEABILITY: The measure of the loss of gas by diffusion through the intact balloon fabric.

PITOT TUBE: A tube with an end open square to the fluid stream, used as a detector of an impact pressure. It is usually associated with a coaxial tube surrounding it, having perforations normal to the axis for indicating static pressure; or there is such a tube placed near it and parallel to it, with a closed conical end and having perforations in its side. The velocity of the fluid can be determined from the difference between the impact pressure and the static pressure, as read by a suitable gauge. This instrument is often used to determine the velocity of an aircraft through the air.

PONTOONS: See Float.

PUSHER: See Airplane.

PYLON: A mast or pillar serving as a marker of a course.

RACE OF A PROPELLER: See Slip stream.

RELATIVE WIND: The motion of the air with reference to a moving body. Its direction and velocity, therefore, are found by adding two vectors, one being the velocity of the air with reference to the earth, the other being equal and opposite to the velocity of the body with reference to the earth.

RIP CORD: The rope running from the rip panel of a balloon to the basket, the pulling of which causes immediate deflation.

RIP PANEL: A strip in the upper part of a balloon which is torn off when immediate deflation is desired.

RUDDER: A hinged or pivoted surface, usually more or less flat or stream lined, used for the purpose of controlling the attitude of an aircraft about its "vertical" axis, i.e., for controlling its lateral movement.

Rudder bar.—The foot bar by means of which the rudder is operated.

SEAPLANE: A particular form of airplane in which the landing gear is suited to operation from the water.

SERPENT: A short, heavy guide rope.

SIDE SLIPPING: Sliding downward and inward when making a turn, due to excessive banking. It is the opposite of skidding.

SKIDDING: Sliding sideways away from the center of the turn in flight. It is usually caused by insufficient banking in a turn, and is the opposite of side slipping.

SKIDS: Long wooden or metal runners designed to prevent nosing of a land machine when landing or to prevent dropping into holes or ditches in rough ground. Generally designed to function should the landing gear collapse or fail to act.

SLIP STREAM OR PROPELLER RACE: The stream of air driven aft by the propeller and with a velocity relative to the airplane greater than that of the surrounding body of still air.

SOARING MACHINE: See Glider.

SPAN OR SPREAD: The maximum distance laterally from tip to tip of an airplane wing, or the lateral dimension of an aerofoil.

STABILITY: A quality in virtue of which an airplane in flight tends to return to its previous attitude after a slight disturbance.

Directional.—Stability with reference to the vertical axis.

Dynamical.—The quality of an aircraft in flight which causes it to return to a condition of equilibrium after its attitude has been changed by meeting some disturbance, e. g., a gust. This return to equilibrium is due to two factors: first, the inherent righting moments of the structure; second, the damping of the oscillations by the tail, etc.

Inherent.—Stability of an aircraft due to the disposition and arrangement of its fixed parts—i. e., that property which causes it to return to its normal attitude of flight without the use of the controls.

Lateral.—Stability with reference to the longitudinal (or fore and aft) axis.

Longitudinal.—Stability with reference to the lateral axis.

Statical.—In wind-tunnel experiments it is found that there is a definite angle of attack, such that for a greater angle or a less one the righting moments are in such a sense as to tend to make the attitude return to this angle. This holds true for a certain range of angles on each side of this definite angle; and the machine is said to possess "statical stability" through this range.

STABILIZER: Any device designed to steady the motion of aircraft.

STAGGER: The amount of advance of the entering wedge of the upper wing of a biplane over that of the lower, expressed as percentage of gap; it is considered positive when the upper surface is forward.

STALLING: A term describing the condition of an airplane which from any cause has lost the relative speed necessary for control.

STATOSCOPE: An instrument to detect the existence of a small rate of ascent or descent, principally used in ballooning.

STAY: A wire, rope, or the like, used as a tie piece to hold parts together, or to contribute stiffness; for example, the stays of the wing and body trussing.

STEP: A break in the form of the bottom of a float.

STREAM-LINE FLOW: A term in hydromechanics to describe the condition of continuous flow of a fluid, as distinguished from eddying flow.

STREAM-LINE SHAPE: A shape intended to avoid eddying and to preserve stream-line flow.

STRUT: A compression member of a truss frame; for instance, the vertical members of the wing truss of a biplane.

SUSPENSION BAND: The band around a balloon to which are attached the basket and the main bridle suspensions.

SUSPENSION BAR: The bar used for the concentration of basket suspension ropes in captive balloons.

SWEEP BACK: The horizontal angle between the lateral axis of an airplane and the entering edge of the main planes.

TAIL: The rear portion of an aircraft, to which are usually attached rudders, elevators, stabilizers and fins.

TAIL CUP: The steadying device attached at the rear of certain types of elongated captive balloons.

THIMBLE: An elongated metal eye spliced in the end of a rope or cable.

TRACTOR: See Airplane.

TRAILING EDGE: The rearmost edge of an aerofoil or propeller blade.

TRIPLANE: A form of airplane whose main supporting surface is divided into three parts, superimposed.

TRUSS: The framing by which the wing loads are transmitted to the body; comprises struts, stays and spars.

UNDERCARRIAGE: See Landing Gear.

WARP: To change the form of the wing by twisting it.

WASH OUT: A permanent warp of an aerofoil such that the angle of attack decreases toward the wing tips.

WEIGHT: Gross. See Load, full.

WINGS: The main supporting surfaces of an airplane.

WING FLAP: See Aileron.

WING LOADING: The weight carried per unit area of supporting surface.

WING MAST: The mast structure projecting above the wing, to which the top load wires are attached.

WING RIB: A fore-and-aft member of the wing structure used to support the covering and to give the wing section its form.

WING SPAR OR WING BEAM: A transverse member of the wing structure.

YAW: To swing off the course about the vertical axis.
Angle of.—The temporary angular deviation of the fore-and-aft axis from the course.

ASSEMBLY OF AIRCRAFT IN A CANADIAN FACTORY

Liberty Engine Construction

THE War Department has issued its first authorized statement regarding details of construction of the Liberty aviation engine. This information may be considered supplementary to that given by Major Vincent at the Annual Meeting in New York last January. The statement reads:

"The designs of the parts of the Liberty engine were based on the following:

"Cylinder.—The designers of the cylinders for the Liberty engine followed the practice used in the German Mercedes, English Rolls-Royce, French Lorraine Deitrich and Italian Isotta Fraschini before the war and during the war. The cylinders are made of steel inner shells, surrounded by pressed steel water jackets. The Packard Company by long experiment had developed a method of applying these steel water jackets. The valve cages are drop forgings welded into the cylinder head. The principal departure from European practice is in the location of the holding-down flange, which is several inches above the mouth of the cylinder, and the unique method of manufacture evolved by the Ford Company. The output is now approximately seventeen hundred cylinder forgings per day.

"Camshaft and Valve Mechanism Above Cylinder Heads.—The design of the above is based on the Mercedes, but was improved for automatic lubrication, without wasting oil, by the Packard Motor Car Company.

"Camshaft Drive.—The camshaft drive was copied almost entirely from the Hall-Scott engine; in fact, several of the gears used in the first sample engines were supplied by the Hall-Scott Motor Car Company. This type of drive is used by Mercedes, Hispano-Suiza and others.

Angle of Forty-five Degrees

"Angle Between Cylinders.—In the Liberty the included angle between the cylinders is 45 deg.; in all other existing twelve-cylinder engines it is 60 deg. This feature is new with the Liberty engine, and was adopted for the purpose of bringing each row of cylinders nearer the vertical and closer together, so as to save width and head resistance. By the narrow angle greater strength is given to the crankcase and vibration is reduced.

"Electric Generator and Ignition.—A Delco ignition system is used. It was especially designed for the Liberty engine, to save weight and to meet the special conditions due to firing twelve cylinders, with an included angle of 45 deg.

"Pistons.—The pistons of the Liberty engine are of Hall-Scott design.

"Connecting-Rods.—Forked or straddle type connecting-rods, first used on the French De Dion car and on the Cadillac motor car in this country, are used.

"Crankshaft.—Crankshaft design followed the standard twelve-cylinder practice, except as to oiling. Crankcase follows standard practice. The 45 deg. angle and the flange location on the cylinders made possible a very strong box section.

"Lubrication.—The first system of lubrication followed the German practice of using one pump to keep the crankcase empty, delivering into an outside reservoir, and another pump to force oil under pressure to the main crankshaft bearings. This lubrication system also followed the German practice in allowing the overflow in the main bearings to travel out the face of the crankcheeks to a scupper, which collected this excess for crankpin lubrication. This is very economical in the use of oil and is still the standard German practice.

"The present system is similar to the first practice, except that the oil, while under pressure, is not only fed to main bearings, but through holes inside of crankcheeks to crankpins, instead of feeding these crankpins through scuppers. The difference between the two oiling systems consists of carrying oil for the crankpins through a hole inside the crank-cheek, instead of up the outside face of the crank-cheek.

"Propeller Hub.—The Hall-Scott propeller hub design was adapted to the power of the Liberty engine.

"Water Pump.—The Packard type of water pump was adapted to the Liberty.

"Carbureter.—A carbureter was developed by the Zenith company for the Liberty engine.

"Bore and Stroke.—The bore and stroke of the Liberty engine is 5 by 7 in., the same as the Hall-Scott A-5 and A-7 engines, and the Hall-Scott twelve-cylinder engine.

Development of the Engine

"The idea of developing Liberty aviation engines of four, six, eight and twelve cylinders with the above characteristics was first thought of about May 25, 1917. The idea was developed in conference with representatives of the British and French missions May 28 to June 1, and was submitted in the form of sketches at a joint meeting of the Aircraft (Production) Board and the joint Army and Navy Technical Board June 4. The first sample was an eight-cylinder model, delivered to the Bureau of Standards July 3, 1917. The eight-cylinder model, however, was never put into production, as advices from France indicated that demands for increased power would make the eight-cylinder model obsolete before it could be produced.

"Work was then concentrated on the twelve-cylinder engine, and one of the experimental engines passed the 50-hr. test Aug. 25, 1917.

"After the preliminary drawings were made engineers from the leading engine builders were brought to the Bureau of Standards, where they inspected the new designs and made suggestions, most of which were incorporated in the final design. At the same time expert production men were making suggestions that would facilitate production.

"The Liberty twelve-cylinder engine passed the 50-hr. test, showing, as the official report of Aug. 25, 1917, records, 'that the fundamental construction is such that very satisfactory service, with a long life and high order of efficiency will be given by this powerplant, and that the design has passed from the experimental stage into the field of proven engines.'

"An engine committee was organized informally, consisting of engineers and production managers of the Packard, Ford, Cadillac, Lincoln, Marmon and Trego companies. This committee met at frequent intervals, and it is to this group of men that the final development of the Liberty engine is largely due."

Foreign Automobile Trade and the War

By John N. Willys* (*Associate Member*)

PROBABLY nothing in late years has done more to carry forward the American export trade than the automobile, which, while possibly considered a peace industry, is just now supplying a very important part in the World War program. Not only has the industry made giant strides in domestic trade, but the aggressive methods of its big men have pioneered the American motor car throughout the world, and in many cases supplied countries with the first American products they have ever seen, thus opening the way for other American goods, because the American motor car has brought credit to American industry in every quarter of the globe.

American motor car makers have introduced American methods and American enterprise, not alone into selling, but in supplying service in cities throughout the world, and last year, even with embargoes on practically all the countries in Europe, American trade exceeded $88,000,000 for 65,792 passenger cars and 14,347 trucks —the biggest proportion of the latter, of course, going to the warring nations.

War Service of the Automobile Industry

Surely no industry in this country can be considered of any greater importance than the automobile industry, with its giant capacity for production. It has supplied the motor transport trucks, officers' cars, ambulances, tractors for guns, tanks, especially equipped vehicles for the airplanes and balloon service, surgeon general's department, automobile kitchens, shoe repair shops and dental trucks, and in addition has taken contracts for the manufacture of many kinds of military and naval articles. These include airplane engines and parts, submarine chasers, marine bomb anchors, gun recoil checks, artillery wheels, shells for guns and numerous other things foreign to the automobile trade.

War contracts already undertaken by the industry aggregate more than $600,000,000. Modern automobile plants, with their extensive equipment of machine tools and hundreds of thousands of expert workers in special trades have unequaled facilities for doing much of the war work required.

The armies having the best transport and the best air service will win. The transport service is organized on a motor truck basis, officers have increased their efficiency many times by the use of motor cars, dispatch riders are mounted on motorcycles, tanks lead the infantry in advances against the enemy, the injured are hurried to the hospitals in motor ambulances, heavy ordnance is hauled by motor tractors, and airplanes keep the commanders advised of enemy movements, drop bombs on his concentrations and depots and pour fusillades from machine guns into his trenches and advancing troops.

The first movement of British forces across the channel was accompanied by the motor omnibuses of London, which carried troops to the front and were then converted into vans to supply fresh beef to the army. Paris was saved from German invasion by a rapid movement of an army of 100,000 men in Paris taxicabs, and Verdun held out against the foe only by a continuous day and night movement of munitions and supplies in a continuous procession of motor trucks.

It was calculated last year that the armies on all fronts were using more than 300,000 motor vehicles.

After commandeering most of the motor trucks and many of the passenger cars in Europe, the French, English and Russian governments turned to the United States to supply the deficiency. During the first three years of the war the United States exported 45,308 motor trucks to England, France and Russia—that is, during the three fiscal years ending June 30, 1915, 1916 and 1917. Nearly all of these were for war purposes, as the exports amounted to only 410 for the two preceding years.

It is not known how many trucks have gone to Europe for the American Army. These do not figure in the summaries of exports as published by the Department of Commerce. But approximately 20,000 trucks had been bought by the United States Army and 10,000 more ordered up to the first of last February, at which time requirements were in sight for from 10,000 to 15,000 more for which orders had not been placed. A considerable part of the first 20,000 had been delivered and sent to their destinations. With the resumption of the German offensive in March the need for redoubled efforts by America indicated the likelihood of heavy increases in orders for army trucks.

Until the seas were cleared of the German menace by the British and French navies, the exportation of motor vehicles suffered in common with all overseas trade. Since then our export trade in automobiles has been maintained at a fairly constant figure, notwithstanding the difficulties of securing shipping space, enormous increases in ocean rates and prohibitions against importation of automobiles by England, France, Italy and India. It has been almost impossible to get automobiles and trucks into Russia and Scandinavian countries for private account. Australia prohibited importation of automobile bodies, but recently modified the prohibition so that it is now possible to import two chassis to every complete car.

Value of Exportations

During the last three calendar years the exports of motor vehicles have been as follows:

1915—Commercial cars, 22,094; passenger cars, 41,864; total valuation, $94,884,393.

1916—Commercial cars, 18,921; passenger cars, 61,922; valuation, $96,673,108.

1917—Commercial, 14,347; passenger, 65,792; valuation, $88,347,739.

Adding automobile engines, tires and parts, the total exports of the industry last year amounted to more than $140,000,000, which very nearly equaled the total exports of all railroad locomotives and cars, all electrical machinery and apparatus and all agricultural machinery combined.

Use of motor vehicles in the United States is of secondary importance only to their use in the war zone in Europe. This is because of the critical transportation and food situation. Everything hinges on transportation, and motor vehicles are an important factor in transportation. Earnest efforts are being made to relieve railroad

Extracts from a paper delivered at the Fifth National Foreign Trade Convention, April 18, at Cincinnati.

*President, Willys-Overland Company.

and terminal congestion by transferring short-haul shipments to the highways.

The number of commercial motor vehicles operating in this country is approaching half a million. It is estimated that they have an average capacity of two tons and can easily average fifty miles a day, including time spent in loading and unloading. Thus they have a combined capacity of 50,000,000 ton-miles daily or 15,000,000,000 ton-miles a year. This is a considerable load to take off of the over-burdened railroads. If all shipments originating within a distance of even twenty-five miles of cities are handled by trucks, which make deliveries direct to consignee, the railroad freight houses will be relieved of all this miscellaneous small freight that now causes so much terminal congestion.

Motor Express Lines

Establishment of rural motor express lines has been a most important influence in stimulating production of foodstuffs. They give farmers an assured means of daily communication with markets and permit them to devote all their time to farm work instead of wasting a large part of it driving long distances to market with loads of produce. There are already hundreds of such truck lines in operation, giving dependable and satisfactory service. Maryland alone has twenty-two, and committees in Washington are at work urging the establishment of more throughout the country.

Return-load bureaus are being established in the eastern states by chambers of commerce, boards of trade, war bureaus of state councils of defense and by motor truck clubs, to insure the operation of motor trucks at full efficiency. The function of these bureaus is to bring together operators whose trucks ordinarily return empty after delivering a load and shippers who are having difficulty making shipments by rail and are glad to avail themselves of the opportunity to have a load carried by truck over the highways.

In the limited time at disposal it is possible only to summarize the many ways in which the third largest manufacturing industry in the country is contributing abroad and at home to the winning of the war. The automobile industry stands solidly behind our Government in its war program; has volunteered its services and resources repeatedly, and has only recently agreed unanimously to reduce by 30 per cent the scheduled production of passenger cars for the year 1918 as a means of helping to conserve the supplies of steel, tin, brass and other materials, reduce railroad freight and the demand on ocean shipping.

Headlamp Illumination

THE recent passage by the New York State Legislature of a law giving authority to the Secretary of State to determine headlamp specifications is likely to be the forerunner of similar legislation in other states. The general situation is such that every effort should be made to conduct tests and carry on experimental work of the sort that will yield information much needed if the legislation is to rest on a scientific and therefore on a sound basis.

The Lighting Division of the Standards Committee is at work on the problem and has cooperated with the Automobile Headlight Committee of the Illuminating Engineering Society in conducting recent tests. The first of these was described on page 302 of the April issue of THE JOURNAL and was discussed at a joint meeting of the New York Section, I. E. S., and the Metropolitan Section of the Society. An abstract of this discussion is given in the following paragraphs.

DR. C. H. SHARP:—In discussions of the headlighting question and in legislation on it we find use made of such phrases as "light sufficient to reveal an object on the road at a distance of so and so many feet" and "dangerous glare or dazzle." No authoritative data giving the photometric values underlying the above conditions seem to exist in the literature of the subject. It is the idea of the joint committee that it is possible to derive such data from experiments in which many people participate so that a consensus of opinion may be reached and that the development of information on these points is a necessary preliminary step to the solution of the headlighting problem.

The tests recorded in the report were made as a first move along these lines. They are not to be considered as in any way constituting the final answer to the complicated questions arising. What has been done merely lays the foundation, but this is a beginning which hitherto has not been made on any such pretentious scale. An application of these results to practical conditions remains to be made in order to see how they conform to the actual requirements of the road. Doubtless any solution of the headlighting problem must be the result of judicious compromise, a balancing of the advantages and disadvantages of different arrangements. It is the purpose of the committee to continue these tests and to endeavor to formulate a set of simple specifications for headlamps, stated numerically in terms which all photometricians will understand, and which will constitute a guide to legislation and regulation of a far more definite and satisfactory character than exists at the present time.

Regarding the tests described in the report, it should be noted that the list of observers included a very representative body of men; not only were illuminating engineers and so-called headlighting experts present, but also a great body of practical automobilists, including representatives of a number of the most prominent automobile associations. Furthermore, the regulatory bodies of a number of states were represented and the traffic force of the New York City police also lent its kind cooperation. The results are of particular value owing to this representative character of the observers.

GEO. H. STICKNEY:—The New York State Legislature this year desired to enact a more satisfactory headlamp law. A committee of the State Senate asked advice of the Illuminating Engineering Society's two committees, one (of which Dr. Sharp is chairman) on the technical questions, and the other, our committee on lighting legislation (of which Mr. Marks is chairman) on legal questions. And so this test, which was being worked up in a general way, was hurriedly made, the Illuminating Engineering Society's committee consulting with the Society of Automotive Engineers. The first requirement was just how far ahead of the car objects should be seen in order to drive safely, for the first problem was that of safe driv-

ing. Then there is the question of determining the illumination necessary to produce that condition, and expressing it in understandable terms.

Our committee went to Albany believing that the proper thing to do was to express the illumination in numerical values, if it was possible to do so. We have been having headlamp lighting laws for a long time, which state that it is necessary to see people at certain distances. The test made rather expresses the futility of any such specifications, because we found variations of 10 or more to 1 as to how much light is necessary to see an object, not under varying weather conditions, character of road surface, and other variables that such a determination in general must involve, but under fixed conditions. It can be readily appreciated how far from satisfactory any specifications expressed in distance of illumination must be.

Our committee recommended that at least the very worst condition represented by our test be incorporated in the law. We found that the Legislature never had considered such a thing, and probably could not, because it did not know by what standard to judge. It was impossible to convince it that our findings should be adopted, so our committees agreed on the idea that the next best thing to be done with the matter was to put it in the hands of a very competent state official, the Secretary of State. He will be empowered to determine specifications for headlamps and headlighting and to determine for the state whether headlamp devices comply with the specifications; and also to determine some method of indicating whether an automobile traveling on the road is complying with the law. I think that this indicates a very hopeful condition; as there are so many people studying this problem, and so much interest in the subject, I feel sure we are going to make rapid progress. I think our societies are going to render a very great service in this connection. In the ordinary sense it is not, perhaps, a war service in which we have been specializing this year, but in another way it is, because the railroads are crowded, and road transportation is becoming important from a war standpoint and must be rendered as safe as possible.

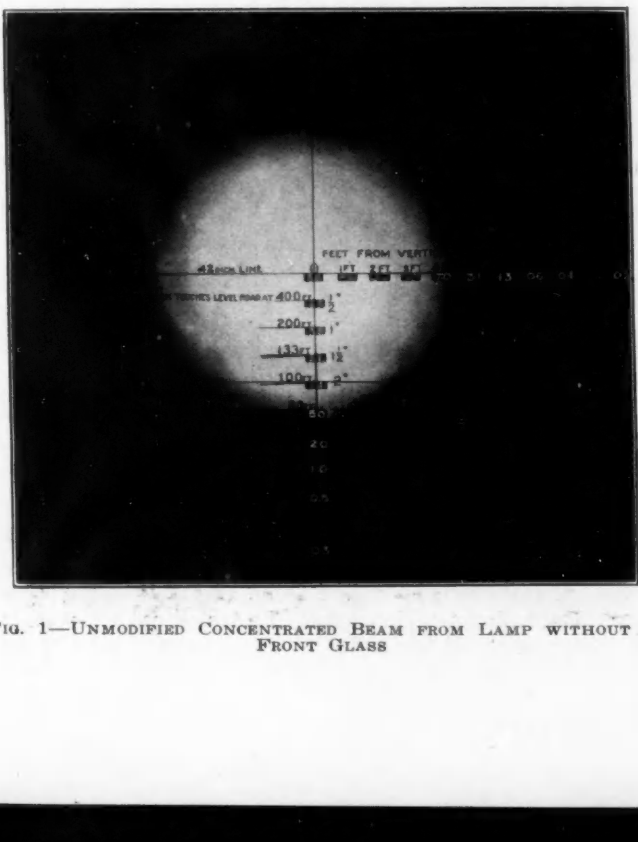


Fig. 1—Unmodified Concentrated Beam from Lamp without a Front Glass

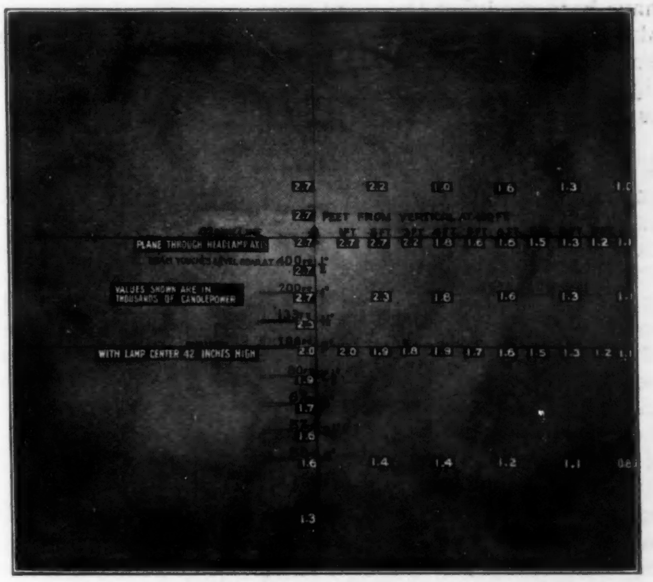


Fig. 2—Beam from Same Lamp and Reflector as Fig. 1, with Scattering Type of Lens

Effect of Lenses on Light Distribution

W. F. Little:—Figures 1 to 5 inclusive (reproduced from photographs of illumination thrown upon a screen) show typical candlepower distributions in the headlamp beam using directive and scattering types of headlamp lenses. The values are given in thousandths of candlepower.

For average conditions the light falling in the eyes of an opposing driver at 100 feet would be approximately 1 deg. above the reflector axis and 7 ft. to the left of the car axis. The combined approximate candlepower for several points is given for each equipment (as represented by the accompanying illustrations) in the following table:

Table I—Approximate Combined Candlepower for Two Headlamps (Based on laboratory tests)

Position	Unmodified Beam	Beam as in Fig. 2	Beam as in Fig. 3	Beam as in Fig. 4	Beam as in Fig. 5
*To the left of car, driver's eye at 100 ft.	1,500	3,000	900	1,000	900
In front of car, driver's eye at 100 ft.	70,000	5,000	3,000	5,000	4,000
In front of car, horizontal 100 ft.	90,000	5,000	9,000	12,000	10,000
In front of car, road level at 200 ft.	70,000	5,000	15,000	25,000	20,000
In front of car, road level at 100 ft.	20,000	4,000	16,000	40,000	30,000
Road level at 200 ft., 7 ft. to right or left of car	1,500	3,000	7,000	30,000	5,000

9¼-in. headlamp with 18 mean spherical cp. incandescent lamp. Lamp mounted at height of 42 in.
*63 in. above road level, 7 ft. to the left of the car axis.

J. R. Cravath:—Having been one of the first to advocate the establishment of some definite specification as to the candlepower to be permitted in the direction of the opposing driver's eye, or the foot-candles incident upon his eye, so that glare regulations may be made more definite, I welcome the test proposed by this committee as calculated to give considerable valuable information as to what limit should be placed on light emitted where it may cause glare. From one aspect the results reported are not at all surprising because Society members who

have been studying the glare question in connection with street and interior lighting for many years fully realize how much interference with vision is caused by even a light of low candlepower as nearly in the line of vision as an approaching automobile headlamp must be.

From another aspect the results are surprising, as some of us who have been studying the headlamp glare problem know that on busy thoroughfares at night we are frequently passing headlamps with safety, and without serious interference with vision, which give considerably more than 239 cp. in the eye at 100 ft. Yet this is the average figure for the 49 observers. Or if one were to take the lowest figure of 80 cp. selected by the most sensitive observer the results are still more surprising. To limit the glare candlepower to any such figure would require such a downward tilt of the beam as to very seriously restrict the usefulness of the headlamps. When we are using devices which give a definite beam of light this question is primarily one of how much tilt shall be given to that beam. The lower the beam is tilted the less the glare in the eye and the more restricted is the distance at which objects are revealed by the headlamp.

Although I approved of the method of making these tests at the time, and still believe they lead to information of much value, further study of the subject and analysis of just what happens when two automobiles are meeting at night has convinced me that a standing test of this kind necessarily leaves out of account one very important factor in the problem which has not been brought out clearly in discussions of this subject, as far as I know. When two automobiles are approaching each other at night with a proper headlighting equipment there is a brightly lighted space of road between them. The road is brightly lighted for each driver by the opposing headlamps. There is thus a stretch of road between the machines which is usually made very plain to both drivers. Neither driver can see past the other lamp to the road beyond. Consequently there is a brief interval just before passing when each driver must go on memory of the road that was illuminated the instant before. This all drivers do without inconvenience, and without thinking about the process. It is a serious mis-

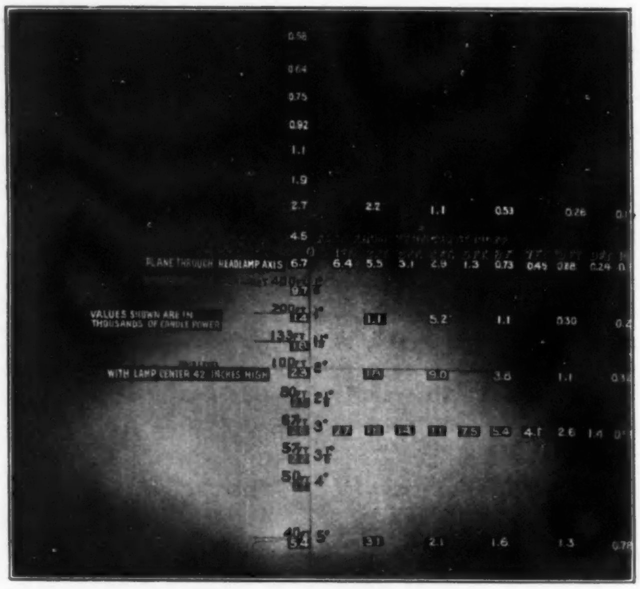


Fig. 4—Typical Triangular Beam
Intensity high at center but low on either side of axis

take, therefore, to assume that the glare should be so restricted that each driver can see by the other car to the road beyond. To make any such assumption would be to restrict the headlamp unnecessarily and increase rather than decrease the danger of night driving. The amount of glare to be permitted in the opposing driver's eyes should be limited to that which will not too seriously interfere with his view of the road when it is illuminated by both headlamps, and to that which will not cause such an after effect as to make it impossible for the eye to recover quickly when it is past. When this is considered it will be seen that a driver is likely to consider tolerable a much greater candlepower in the glare zone when he is actually driving, with both cars in motion, than under the condition of this test where the efforts of many of the observers evidently were to see past the other headlamp to the road beyond.

Tests With Moving Cars

In order to try out what certain candlepower restrictions as to glare would mean in actual practice I have made a few tests with a car equipped so as to give a known candlepower in certain directions in the region of an opposing driver's eye. These tests, although very limited, both in number and scope, are submitted for what they may be worth in contributing to the solution of the problem and the drawing of satisfactory specifications.

Two cars used in these tests were equipped with prismatic lenses giving oval beams of light about twice as wide as high; lamps were of a nominal rating of 21 cp., while reflectors, 7½ in. diameter, 32 in. above the road, were pointed so that the headlamp beams overlapped on the road. The tilt of the beam to get greater or less candlepower in the glare zone was accomplished by bending the headlamp arm. Exact candlepower adjustments were made on one car only, the other being adjusted simply by inspection to give an apparently similar distribution on the road. After an adjustment was made the cars were driven repeatedly past each other on a dark asphalt street with no street lights, the test course having some level and some slightly rolling contours. Each observer drove past the tested car repeatedly until satisfied to render a judgment as to its glare. Each

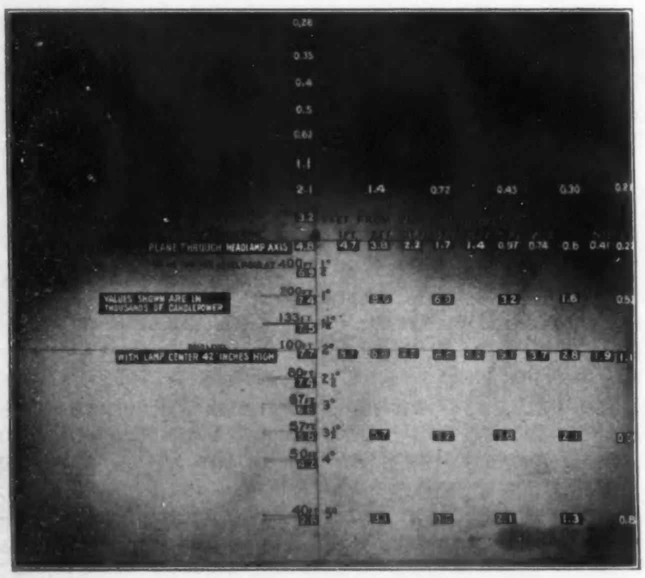


Fig. 3—Beam from a Deflecting Lens
Light of relatively high intensity at and near the horizontal, falling off rapidly on either side. Light intensity extends considerably above horizontal but over a very narrow angle

observer also drove a number of miles in the car over dark roads to form a judgment as to the driving light.

The technical data as to the two adjustments of headlamps tested are given in Table II.

Adjustment 1 was pronounced satisfactory as to glare by three drivers after the repeated meetings described. Four drivers pronounced this adjustment a very satisfactory driving light after driving behind it a number of miles on dark roads.

Adjustment 2 was pronounced by the same three drivers as a little more than they would like to stand for in the way of glare. Although they were able to drive past it without much difficulty, all felt that it was approaching the danger limit. Later this same car was stopped by a policeman on one of Chicago's level boulevards and the driver told to fix his headlamps when he got back to the garage.

In connection with specifications for headlamp glare it is of interest to note that the first attempt at a definite candlepower limitation in the glare zone has been made by Commissioner C. M. Talbert of the city of St. Louis, who has motor-vehicle matters under his charge. At the municipal automobile headlamp testing station which he has established for the use of motorists a limitation of 1200 cp. above the 42-in. level, or 0.075 ft.-cp. at 40

TABLE II—TECHNICAL DATA FOR TWO ADJUSTMENTS OF LIGHT INTENSITY

Point of Measurement on Level Road 100 Ft. Ahead of Car		Foot-Candles (Normal)	
		Adjustment 1	Adjustment 2
63 in. high	7 ft. to left of center line	0.051	0.080
63 in. high	On center line	0.044	0.116
63 in. high	7 ft. to right of center line	0.051	0.122
42 in. high	7 ft. to left of center line	0.075	0.157
42 in. high	On center line	....	0.298
42 in. high	7 ft. to right of center line	....	0.080
6 in. high	7 ft. to left of center line	0.188	....
6 in. high	On center line	0.282	....
6 in. high	7 ft. to right of center line	....	....

ft. distance, has been established for glare. A minimum limitation of 500 cp. to reveal objects on the road at 150 ft. distance has been established.

With appliances now on the market it is entirely possible to produce a satisfactory driving light without dangerous glare if the motorist is willing, as he should be, to confine himself to speed not much over 20 m.p.h. While the glare from such headlamps may be somewhat annoying, it is not really dangerous, and for the present will have to be put up with for the sake of securing a fairly good driving light. The man who wants to exceed safe and legal speed limits and have enough light on the distant road to reveal obstructions in time to stop will probably have to let his desires remain unsatisfied for some time to come.

NORMAN MACBETH: It seems that there was remarkable agreement among the observers. For instance, if we were endeavoring to obtain from some 40 observers an opinion as to what is the minimum illumination needed for reading a newspaper, they might vary with a difference of one-half to twice as much candlepower, and yet, as a matter of fact, the illumination might be increased three or four times as much without creating any difficulty.

The forty-nine observers who took part in the headlamp illumination test were referred to by number only in the table printed on page 303 of the April issue of THE JOURNAL. The names of these forty-nine observers

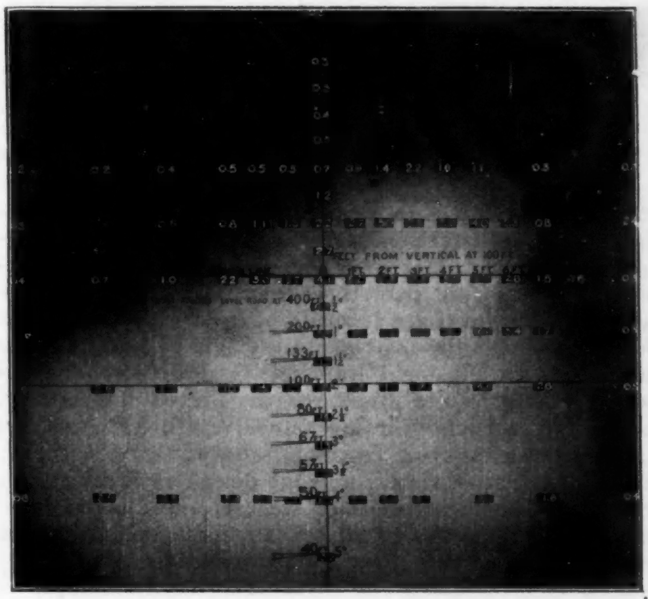


FIG. 5—BEAM FROM A LENS THROWING CONSIDERABLE LIGHT ABOVE AND TO RIGHT OF REFLECTOR AXIS, BUT LITTLE TO THE LEFT ABOVE HORIZONTAL

are given below, but they are not listed in the same order as the observers listed in the table:

A. H. Taylor, assistant physicist, Bureau of Standards, Washington.
A. B. Parker, Deputy Secretary of State, Albany, N. Y.
C. C. Grant, publicity department, office of Secretary of State, Albany, N. Y.
Fred. Kuser, special inspector, State Motor Vehicle Department, Trenton, N. J.
Walter S. Lefavour, Motor Vehicle Department, State of New Jersey, 136 Tichenor Street, Newark, N. J.
A. L. Atwood member State Board of Public Roads, Providence, R. I.
M. M. Van Buren, member State Board of Public Roads, Aquidneck, R. I.
George R. Wellington, chief clerk, Automobile Department, State Board of Public Roads, Providence, R. I.
Lieut. A. Howe, in charge of Motorcycle Police, New York.
Sergeant J. F. Contait, Motorcycle Squad No. 2, New York.
Preston S. Millar, general manager, Electrical Testing Laboratories, New York.
Dr. C. H. Sharp, technical director, Electrical Testing Laboratories, New York.
W. F. Little, engineer in charge of photometry, Electrical Testing Laboratories, New York.
G. L. Diggles, assistant superintendent of lamp inspections, Electrical Testing Laboratories, New York.
Frederick R. Hutton (deceased), chairman Technical Committee, Automobile Club of America, New York.
John J. McInerney, counsel, New York State Motor Federation, Rochester, N. Y.
T. D. Pratt, executive secretary, Motor Truck Club, New York.
Mancius S. Hutton, laboratory engineer, Automobile Club of America, New York.
E. J. Dailey, Jr., illuminating engineer, New York.
S. C. Rogers, illuminating engineer, General Electric Co., West Lynn, Mass.
Bradford H. Divine, president Divine Brothers Co., Utica, N. Y.
Nat. Mallauf, vice-president, Motor Haulage Co., New York.
Miss Z. N. Corraz, Electrical Testing Laboratories, New York.
C. Gifford, Electrical Testing Laboratories, New York.
Joseph A. Ackerson, New York.
Alfred F. Camacho, New York.
Irving B. Cary, New York.
Ellis H. Custer, New York.
H. W. Ditman, New York.
W. Douglass, New York.
Evan J. Edwards, Cleveland, Ohio.
George M. Graham, New York.
Sawney Hall, Mt. Pleasant, Pa.
James S. Hemstreet, New York.
Fred. P. Kelly, Chicago.
C. T. Klug, New York.
William Long, New York.
W. A. McKay, New York.
S. P. McMinn, New York.
Henry MacNair, New York.
L. B. Marks, New York.
H. L. Reed, Albany, N. Y.
A. W. Seaman, New York.
Lewis J. Stewart, New York.
James F. Toomey, Boston.
F. F. Wocel, New York.
M. W. Hanks, Standards Manager, S. A. E., New York.
R. S. Burnett, S. A. E. Standards Office, New York.
C. E. Heywood, S. A. E. Publication Office, New York.

International Aircraft Standards

THE American Aircraft Commission, which spent several weeks in Europe recently in conference with engineering representatives of the Allies, on the formulation of harmonious specifications of materials and mounting and other dimensions of parts for aircraft, was constituted of three representatives from the Society, three from the International Aircraft Standards Board, two from the United States Signal Corps, and one each from the National Advisory Committee for Aeronautics, the Bureau of Standards, the United States Navy, the American Society of Mechanical Engineers, and the American Society for Testing Materials. The request that the various societies appoint delegates having been acted upon, the whole matter was referred to the Government, and the personnel of the Commission decided upon after consultation with representatives of Governmental, manufacturing and engineering organizations.

The British Air Board (now the Air Council) had, in conjunction with the British Engineering Standards Committee (now the British Engineering Standards Association), formed a Sectional Committee to deal with the standardization of the components of aircraft and aircraft engines, and nominated several subcommittees to consider the details of the different branches of the subject. The British organization had, of course, been in communication with the French and Italian standardization committees.

The belief that the conferences just had would constitute a real advance, and facilitate ultimate international standardization, was borne out. The delegates had advisory powers only, the arrangement being that after conferring they would make recommendations to the authorities by whom they were appointed.

The members of the American Commission attended scores of sessions and conferences with their European brethren. Many aircraft and engine manufacturing plants were visited. Government factories, repair stations, laboratories and salvage depots were inspected and their methods studied. A formal International Conference was held in London, representatives of France, Italy, Great Britain and the United States being present. The general subject of cooperation of the Allied Powers, through exchange of ideas and standardization of aircraft materials, was discussed. All were in favor of a permanent aircraft standards organization representing at least five of the Allied Nations.

The following branches of the service and organizations of our Allies were represented in the conferences:

British—Technical Department of Aircraft Production and Aeronautical Supplies of the Ministry of Munitions, the Admiralty, the National Physical Laboratory, the Aeronautical Society of Great Britain, the Society of British Aircraft Constructors, the Aircraft Steelmakers' Committee, the Technical Committee of Motor Industries, Aeronautical Inspection Directorate, Brass and Copper Tube Association, British Electrical and Allied Manufacturers' Association, British Ignition Apparatus Association, Cable Makers' Association, ball-bearing manufacturers, the Weldless Tube Association, the Irish Power Loom Manufacturers' Association, the Iron and Steel Institute, and the Steel Research Committee.

French—Section Technique de l'Aeronautique, and Service de l'Aviation.

Italian—Mission pour l'Aeronautique Militaire Italienne a l'Etranger, and Services d'Approvisionement de l'Aviation Italienne.

The prime objects of the conferences were to facilitate the sending of most usable supplies to England, France and Italy from the United States and to settle mutually satisfactory standards and specifications; to make parts, fittings and instruments interchangeable on aircraft produced in the different countries.

England and France and Italy, during the past three years, have worked with an energy never before equaled, and have made tremendous strides in aircraft design and production. The members of the American Commission were highly encouraged by what they saw. The spirit of cooperation in which they were met, the wholehearted expression of desire to work jointly to achieve the largest result toward the one thing worth considering today, were most gratifying.

The production of our Allies is now large. The work of their technical and scientific men in aircraft lines has been carried on in a very extensive and effective way.

Specifications for Steels

Progress was made at the conferences abroad in the formulation of Allied standard specifications for aircraft steels, using the current American, British, French and Italian specifications as a basis; covering both the general procedure for testing and the chemical and physical requirements of wrought steels.

Fabrics

The American standard fabrics have been submitted for test, and specifications have been recommended.

Dopes

The British specifications and methods of inspection were studied carefully. The science and economics of the manufacture of these articles are, of course, important.

Radial Bearings

In the metric sizes the S. A. E. and the British ball-bearing series are identical, except that six S. A. E. sizes have not been included in the British list. A revision of tolerances and limits recommended by the British and the American delegates is under consideration. Limits of eccentricity in radial bearings and outside dimensions of thrust bearings were other subjects of study.

Spark-Plugs

The 18-mm. spark-plug, incorporating the best features of the British and the S. A. E. plugs, has been recommended for use on American and British stationary cylinder and rotary engines.

Magnetos

The dimension specifications for British and for American magnetos are substantially the same, with the exception of one dimension of magneto space. The American specification of the taper as one in five is the same as the British specification of the taper as one in ten, owing to the fact that the British refer to the slope of the conical surface to the axis.

Nomenclature

Representatives of the National Advisory Committee for Aeronautics and of the Society are conferring with the committee of the Aeronautical Society of Great Britain on nomenclature.

Instruments

It is necessary to standardize further the connections and attachments and also the general character of the indication of instruments.

Unification of Units of Measurement

The plan, provisionally adopted by the subcommittee of the International Commission on Pipe Threads, which met in Paris July, 1914, for a standard method of designating units of construction, was discussed, with reference particularly to screw threads and gear-wheel teeth, the idea being to seek a unit which could be used when either the inch or the metric system is employed. Taking screw threads as an illustration, a system of notation was outlined by which each screw would bear a distinctive number based on the diameter in eighths of an inch, and the pitch in the number of threads per inch or per 127 mm. (which equal five inches), without reference to the unit in which the measurement might be made. For example, a ¾-in. U. S. standard bolt having 10 threads per inch would be designated a "6 x 50" bolt in countries using the metric system. The selection of 127 mm. as the length over which the number of threads should be stated in countries using the metric system is based on the fact that this gives *whole* number turns, these being five times the number of threads per inch.

The very difficult problem of bringing together the advocates of the metric and of the inch bases is, of course, in abeyance, but it is felt by some that the plan outlined above may afford the first step.

Plywood and Cements

The British specifications for plywood and for casein cement were discussed in detail.

Glue

The practices in the preparation and use of glue are much the same in the United States and Great Britain. Mechanical methods of application and electrical methods of heating are used largely here, but neither of these methods is common in England. Comparative tests of British and American methods of testing glue are being made.

Timber

The question of spruce supply was naturally discussed. Kiln procedure has been simplified, the results being satisfactory almost invariably. It is appreciated by all that the splicing of wood is an important subject. Additional approved designs of laminated and box spars will be recommended.

Structural Tubing

The possibilities of further development in the methods of drawing and heat-treating tubing are being studied, with promise of marked improvement.

Lubricating Oil and Gasoline

The gasoline and lubricating oil questions require continued attention, to assure adequate supplies of proper quality. Compounded oils will be furnished where required, as well as grades of gasolines of proper homogeneity and low end-point.

Propeller Hubs and Fittings

Propeller hub and fittings practice will be further unified so far as shall prove advisable and possible.

Water and Fuel Piping

Coordination of water and fuel piping standards is largely dependant on thread practice. The use of outside dimension only for nominal diameters of metal tubing has been recommended.

Electrical Apparatus

The practice in electrical apparatus peculiar to aircraft, such as signal lights, radio, generators, batteries, heating and protective devices, is under consideration in view of more extensive use.

Wheels and Tires

The British and the American practices in wheels and tires are substantially in accord. Discussion is being had as to the advisability of extending the list of wheel sizes which has been adopted here.

The number of tire sizes will be kept to the lowest possible minimum.

Steel Wire Cables

The British and the American steel wire cables are sufficiently alike to be practically interchangeable. The same thing is true of high-tension steel wire.

Turnbuckles

It is felt that similarity of design is not necessary in turnbuckles, satisfactory interchangeability being securable if the fork-end and pin dimensions are standardized.

Gasoline Rubber Tubing

Comparative tests are being made of gasoline rubber tubing made to British and to United States specifications.

Installation of Apparatus

Standardization will be effected so far as possible in the location, mounting, size, and indication of direction and method of operation of instruments and apparatus.

The Work in Hand

The single aim in considering the various matters is to ascertain to what extent we can, without interfering with our productive capacity, adopt European standards with advantage; to what extent we can assist more effectively in cases of European conformity with our practices; following the course that will bring the best results. That which does not contribute to the winning of the war is of quite secondary importance. Anything that does contribute to the winning of the war is obviously of prime importance.

Current Standardization Work

THE meetings of Divisions of the Standards Committee scheduled for the near future are listed below:

Stationary and Farm Engine Division, 10:00 a. m., June 3 and 4, Hotel Sherman, Chicago.

Data Sheet Division, 1:30 p. m., June 4, S. A. E. Headquarters, New York.

Aeronautic Division Meeting

The subjects of airplane nuts, bolts, and turnbuckles were considered at the April 10 meeting of the Aeronautic Division, held at S. A. E. headquarters in New York. The following attended: F. G. Diffin, E. H. Ehrman, Grover C. Farnsworth, J. B. Johnson, Standards Manager M. W. Hanks, and Robert S. Burnett.

The object of this meeting was to review certain proposed changes in these standards suggested by the Signal Corps, and to arrange for a final agreement between the Signal Corps, Navy and S. A. E. whereby the manufacturers can produce the various details on regular shop orders and furnish both the Signal Corps and Navy with the same product without having to run through special orders.

Messrs. Diffin and Ehrman had just returned from the Anglo-American Conference in London with the latest information covering English practice of construction as well as organization.

Mr. Diffin spoke of the necessity of immediately correlating all aircraft manufacture and development work under one head. This plan is found most effective by England after three years of war experience.

Bolt Diameter Limits

The Signal Corps has suggested that the maximum bolt diameter be 0.001 in. less than the nominal diameter with 0.002 in. clearance. This was done in order to avoid specifying any clearance in the diameters of holes on drawings.

Mr. Ehrman called attention to the fact that the aircraft bolts are used in wood and are almost always much longer than engine bolts, consequently it is not practicable or advisable to work to as close limits, and that it is preferable to specify the maximum diameter as nominal rather than 0.001 in. less as it will insure an average greater strength of bolts. After further remarks by Mr. Ehrman, it was unanimously agreed, in view of the fact that many companies are already acquainted with the S. A. E. limits, and provided with tools in accordance with them, that the S. A. E. limits be maintained except on the small sizes Nos. 8 and 10, where the limit be +0.000 —0.003 in place of +0.000 —0.004 in. In view of the importance of not permitting the diameter of the bolt to exceed the nominal fractional size, it is recommended that all decimals be given to four places, and that the last figure shall not be greater than its actual value.

Bolt Thread Lengths

Discussing the proposal of specifying only the thread length and not the usable length of thread (as specified by the S. A. E.), Mr. Ehrman called attention to the fact that without the usable length factor, screw makers will not know the length to make the thread because of the uncertainty as to whether the dimension means usable length or total length. It was unanimously agreed to adhere to the S. A. E. standard, which states the minimum length of usable thread and specifies maximum of four extra threads.

Bolt Head and Nut Dimensions

It is believed that information concerning the basis of bolt head and nut design should be given so that our present standards will be more thoroughly understood and in event of extension a basis of calculation be available.

The practice is that the thickness of full strength nuts should equal three-quarters of the diameter of the bolt, and that full strength bolt heads, thin nuts for shear bolts and check nuts should each equal half the diameter of the bolt.

It was unanimously agreed that the practice stated above shall govern bolt and nut design as far as practicable, but all thin aircraft nuts in sizes less than 1/4 in. shall be according to S. A. E. full strength plain nut practice.

Bolt Head and Nut Chamfer

Attention was called by the Signal Corps to the difficulty in keeping the 15-deg. chamfer recommended by the S. A. E. for airplane bolts and nuts from cutting below the short diameter of the hex. If the chamfer projects below the short diameter of the hex it decreases the bearing surface and therefore produces cupping of the washer, and a natural loosening of the bolt. It was agreed that the underside of bolt heads and the face of nuts shall be cut back from 0.010 to 0.015 in. to produce a washer face with diameter equal to the short diameter of the hex.

Bolts with Threaded Ends

Mr. Ehrman stated that the British were using extensively bolts with threaded ends, made from the rod with a short full thread at one end and the regulation thread at the other. The nuts were screwed on tightly, burred over and in some cases brazed with spelter. It was recommended that a specification for aircraft bolts made from rods threaded at both ends with nut heads brazed on with low fusing point zinc spelter, be prepared and submitted to the Signal Corps, Navy, S. A. E. and manufacturers for constructive criticism, with a view of ultimately adopting it as an acceptable standard for long aircraft bolts.

Plain Ball Hexagon Bolt Heads

It was agreed that the B/4 dimension (height of hexagon face which is equal to one-quarter of the small diameter of the bolt head) of plain ball hexagon bolt heads remain on the drawing (Data Sheet 45-L and 45-N), that it be marked "minimum" and also a note be added stating that "this dimension is specified to safeguard the width of wrench surface."

Turnbuckles

It is believed that the S. A. E. turnbuckle specification* when certain sizes are made wider, as suggested by the Signal Corps, will conform closely to the English practice. The new S. A. E. design is interchangeable with 90 per cent of the turnbuckles on the American market.

Mr. Farnsworth, representing the Navy, said that the S. A. E. specification as submitted is satisfactory to that Department. The matter of protective coating has been considered and the Navy has issued a tentative specification of Zinc Coatings for Metal Parts (No. 39), which will possibly be used on turnbuckles. The Navy has sent men to various plating plants to instruct them in the proper method of applying the zinc coatings.

Mr. Farnsworth stated that at a recent meeting of the platers at the Bureau of Standards, the consensus of opinion was that sand-blasting is the best means of cleaning the article preparatory to zinc plating. Tumbling was also suggested, but this is not as satisfactory as sand-blasting.

According to Mr. Johnson, representing the Signal Corps, it approves of the S. A. E. turnbuckle specification as presented except for No. 61 S and L fork-end. In this the slot dimension H should be increased from 0.688 to 0.750 in., and for sizes 80L it should be increased from 0.688 to 0.781 inch. There seem to be no objections to this increase other than that there will be cases where the washer will have to be welded on if the turnbuckles are used with narrow clips.

The Signal Corps also suggests that in the No. 32 size the 0.109-in. slot be omitted, as it represents questionable clip practice even with steel of 125,000 lb. per sq. in. tensile strength.

At a meeting of the Aeronautic Division, held May 5 at the New Willard Hotel, Washington, the subjects of rigging and components, turnbuckles and associate fittings, screws, bolts, timber drying processes, glues and cements were taken up.

Data Sheet Division Meeting

A meeting of the Data Sheet Division was held on May 3 at S. A. E. headquarters in New York, attended by P. M. Heldt (chairman), A. C. Bergman, Dr. Harrison Craver (conferee) and R. S. Burnett.

Indexing System

The matter of a new indexing system for the data sheets was discussed, but it was decided not to make any changes at this time in view of the fact that hundreds of S. A. E. Handbooks are in active use in the different departments of the Government and of manufacturers doing work for the Government. Owing to this fact, it is thought best to maintain the present system, with the comprehensive index plan.

After a review of the Sectional Index presented some time ago, the Division recommended that this be brought up-to-date and a new section added which will be entitled Special Equipment and Fittings Section, with subdivisions of Aeronautics, Automobile, Marine, Motorcycle and Tractor classifications.

Size of Data Sheets

The subject of enlarging the Handbooks was considered. In reviewing the former recommendation (Sept. 28, 1917) the Division decided that the advantages to be gained by the larger size sheets ($8\frac{1}{2}$ by 11 in.) are considerably overbalanced by the reasons for retaining the present size ($4\frac{1}{4}$ by $7\frac{1}{4}$ in.) Some of the reasons for increasing the size are:

1. Illustrations could be made larger.
2. More space for lengthy specifications.
3. Larger type could be used.
4. The Handbooks would not be so thick.
5. It would be possible for engineers and users of the Handbook to file letter size drawings, etc., with the data sheets.

Reasons for retaining the present size are:

1. Practically all illustrations can be printed distinctly on present size sheet.
2. There is no objection to printing lengthy specifications on two or more pages. Comparatively few tabulated specifications require more than one page, but where they do, two pages facing each other can be used. This is in accordance with present practice.
3. A satisfactory type size for both text and tabulated specifications is now being used.
4. The greatest possible thickness of the present Handbook is not objectionable.
5. Handbooks are not intended for filing miscellaneous sheets.
6. Considerable objection has been voiced by users in that large books would take up too much desk or table room, where they are generally used the most.
7. The considerable expense to the Society and the inconvenience to members in making a change is objectionable.

Mr. Bergman stated that after the war, there would probably be much new and revised data available, and that the change in size should be made later, if at all.

As the type of shaft key, commonly referred to as the Woodruff key, has been incorporated in some of the S. A. E. Standards Specifications, it was thought desirable to publish a table of these keys in Volume II. of the Handbook. Tables of dimensions covering these keys have been made up from information obtained by Mr. Heldt.

Altitude Curves

The Division reviewed a number of curves sent to the Standards office by C. F. Hopewell, who suggested their publication in Volume II. Of these curves, the Division recommends the following as desirable for the Handbook: Temperature-Altitude Curves, showing summer, autumn and winter gradients; Specific Weight-Temperature, Conversion of Inches Head of Water to Pounds per Square Inch, and two Pressure-Altitude curves, one reading from 0 to 5000 ft. and the second from 5000 to 25,000 ft.

Electrical Equipment Division Meeting

The Electrical Equipment Division held a meeting on April 15 at the Detroit Section office in the Kresge Building, Detroit, which was attended by the following: W. A. Chryst, O. F. Conklin, F. W. Edwards, W. A. Frederick, T. L. Lee, B. M. Leece, A. D. T. Libby, C. Marcus, H. E. Rice, C. E. Wilson and Standards Manager M. W. Hanks.

Starting Switches

In view of the fact that it was found impossible to change the mounting dimensions of the various starting switches to comply with suggestions made, it was decided to discontinue further work on the subject. The location of starting switches was considered, and the division

*See page 308, April issue, The Journal, for details of proposed specifications.

recommends that when possible the starting switch be mounted on the chassis to facilitate assembling and testing.

Cable Terminals

In view of the fact that cable terminals of the closed-sleeve type may appear solidly connected at the clip mouth, although the connection may not be firm at the bottom, and since the solder cannot be inspected, the division decided to recommend that terminals be of such design as to admit of ready inspection of the soldered joint. A committee was appointed to review the subject with the object of making definite recommendations at a later meeting, this committee to give major attention to the terminals used in starting motor circuits, but also to give consideration to terminals for lighting and ignition circuits. O. F. Conklin (chairman), T. L. Lee and C. Marcus constitute this committee.

Marking of Fuses

It was recommended that fuses, when their dimensions agree with those in the National Electric Code, shall be marked according to the requirement of that Code. The present fuse specification for gasoline automobiles, sheet 48h, Vol. I, S. A. E. Handbook, provides for a definite dimension and marking of both current and voltage values, but does not state where they shall be marked. It was recommended that the first sentence, second paragraph on this sheet be changed from, "Fuses to be marked '25 volts' and their carrying capacity," to read, "The voltage (V) and carrying capacity (C) shall be plainly marked on one of the ferrules of each fuse," this recommendation to apply to all fuses whether of standard or special size.

Mounting Dimensions for Electrical Instruments

A committee consisting of C. E. Wilson (chairman) and A. D. T. Libby was appointed with instructions to confer with makers of automobile gages and electrical instruments with the aim of formulating a recommendation for mounting dimensions for all types of indicating gages, exclusive of speedometers.

Distributor Mounting Dimensions

Certain recommendations on distributor mounting dimensions were made, and it was decided to submit these to manufacturers of engine and ignition apparatus for their constructive criticism.

Generator Bracket Mounting

As the subject of generator bracket mounting requires considerable study, a committee, consisting of W. A. Frederick (chairman), T. L. Lee and B. M. Leece, was appointed to make a thorough investigation of the subject and report at a later meeting.

Starting Motor Mounting

In order to make the present S. A. E. starting motor flange conform to latest practice the division is giving this subject careful study in cooperation with manufacturers.

Starting Motor Pinion.—Attention was called to the fact that starting motor pinions now vary in the number of their teeth from 9 to 13, and that as long as there is no standard, the engine builder cannot maintain definite gear centers. In view of this situation it was recommended that the practice of using 11-tooth pinions, 8/10 pitch, be followed wherever possible.

No. 4 Flange Mounting.—In view of the growing demand for larger starting motors for marine work, it was recommended that the subdivision on generator mountings report on the advisability of working up dimensions for a No. 4 flange.

Nomenclature Division Meeting

A meeting of the Nomenclature Division was held on the afternoon of April 22 at the S. A. E. headquarters, New York. Frederick R. Hutton (chairman), H. R. Cobleigh, L. M. Griffith, M. W. Hanks, R. S. Burnett and C. C. Phelps attended the meeting. As the nomenclature work of the Society at present covers only automobile pasenger cars, it was decided to take up the work of recommending a standard nomenclature in the following order: Aeronautics, Tractor, Motorcycle, Truck, Marine.

Nomenclature for Aeronautics

Mr. Griffiths presented to the Division, Report No. 15, entitled "Nomenclature for Aeronautics," published by the National Advisory Committee for Aeronautics, reprinted from the third annual report and dated 1918, Government Printing Office. The Division decided to review report No. 15 and a considerable part of the meeting was devoted to perusal of its terms and definitions. (This nomenclature is reprinted in full on page 358 of this issue of The Journal.)

Mr. Cobleigh submitted a partial list of tractor terms and definitions and a list of terms used in tractor work, but not yet defined. Further work on this tractor nomenclature was postponed until a later meeting.

A later meeting of the Nomenclature Division was held on May 13, at the Engineers' Club, 1315 Spruce Street, Philadelphia, attended by H. R. Cobleigh, L. M. Griffith, Herbert Chase and C. C. Phelps. This meeting was devoted to a discussion of the best form in which to publish these various nomenclatures so that they would be of most use to those who will use them. It was the sense of the meeting that the most useful form of nomenclature would be arranged in two parts, Part 1 showing group arrangements of the various parts, with diagrams indicating the relative positions of the various parts and the names of the parts numbered on the diagram, being listed below each diagram. Part 2 would comprise an alphabetical list of the parts followed by definitions where words are not fully self-explanatory. The advisability of listing alternative terms with cross-references to the standardized terms was also considered. The advantages of the Dewey decimal system for indexing such nomenclatures was discussed and it was thought feasible to apply this system so that a number inserted after each name in the alphabetical list would refer the reader directly to the page and line of the other list containing the same name.

It was believed that a separate nomenclature covering the powerplant proper, could be gotten up to apply to all of the automotive fields. The aeronautic, tractor, motorcycle and other fields to be covered by nomenclatures would then be taken care of in separate nomenclatures which would also include such terms pertaining to the powerplant as are peculiar to each field. With a definite

policy and plan of procedure laid out for the various subdivisions it is felt that the resulting nomenclatures will be uniform in style and of maximum service.

Tire and Rim Division Meeting

A meeting of the Tire and Rim Division was held April 13 at the Statler Hotel, Cleveland, attended by J. E. Hale, acting chairman, E. K. Baker, C. C. Carlton, E. I. Heinsohn, E. G. Hulse, O. H. Jobski, G. H. Lewis, Bert Morley, J. D. Tew and Standards Manager M. W. Hanks.

A review of 45 makes of trucks shows the sizes in common use are as follows:

Table I—Range of Present Truck Sizes

Capacity in Tons	¾*	1	1¼*	1½	2*	2½	3	3½*	4	4½	5*	6	7*
Number of companies making each size..	9	24	3	17	35	7	8	24	8	1	25	5	5

Assuming the popular capacities marked * would satisfy commercial requirements, the list would be as follows:

¾ ton	3½ ton
1¼ ton	5 ton
2 ton	7 ton

The number of tire sizes required for this list of six different truck capacities should be less than when thirteen different capacities are used.

At this meeting it was recommended that the report of J. E. Hale, covering the subjects of truck capacities and tire equipment, be sent to truck manufacturers for comment and constructive criticism. A copy of this report has been sent out with a request that the various truck manufacturers advise the Standards Committee as to their opinions on the following questions: First, in view of the list in Table I (reproduced above), showing thirteen different sizes of trucks in use at the present time, covering a range from ¾ to 7 tons, is it advisable to adopt a limited series of six sizes similar to the suggestions in Table II?

Second, are definite sizes recommended, as shown in Table II, so as to simplify the tire list? This suggested simplification is in line with the desires of the Commercial Economy Board of the Council of National Defense.

Third, is the simplified series of pneumatic tire sizes listed in the bottom section of Table III, on page 374, advisable?

The report of Mr. Hale stated that "At present the public has to support a certain amount of extravagance in motor truck merchandising and service which could be eliminated by a simplification in the number of models offered to the trade, together with limitations in the choice of tire sizes for these trucks."

Believing that some of these sizes are really superfluous, Mr. Hale suggests standardizing trucks according to the load capacity, and suggests tentatively as the basis for discussion the following sizes: ¾, 1¼, 2, 3½, 5 and 7 tons.

"It is further suggested that any standard which might be worked out include maximum average and minimum weights for front and rear ends of the truck." Proposals along this line are indicated in Table II.

The proposed standardized sizes of pneumatic tires are shown in Table III.

Mr. Hale points out the need for solid tire standardization, mentioning the case of the 2-ton truck as an example of the present conditions. The solid-tire sizes for these trucks are as follows:

Front	Rear	
34 x 3½	34 x 3½	Dual
36 x 3½	36 x 3½	Dual
34 x 4	36 x 4	Dual
36 x 4	34 x 5	Single
	34 x 6	Single
	36 x 6	Single
	36 x 7	Single

Inasmuch as twenty-two different sizes of solid tires are called for as original equipment by truck manufacturers, it is considered desirable to limit this range of tire sizes for each of these various models of trucks.

At the request of the Commercial Economy Board the War Service Committee of the Rubber Association of America has recommended the adoption of the schedule of tire and rim sizes indicated in the lower section of Table III. The Rubber Association of America requests cooperation of the automobile industry, to the end that it conform to these sizes of tires and rims on cars to be manufactured for the 1919 season, the manufacture of which, in most instances, will begin July 1, 1918. The adoption of that schedule will reduce the number of sizes and styles manufactured and carried in stock by both tire manufacturers and their customers from approximately 200 to 28, and there will be but seven sizes of rims and nine sizes of tires, adequate to equip with pneumatic tires any motor vehicle up to the 2-ton truck.

Table II—Proposed Standards for Truck Capacities and for Corresponding Tire Equipment

Rated Load Capacity of Truck in Tons	Front End of Truck			Rear End of Truck		
	Average Total Weight on Both Tires, lb.	Tire Equipment		Average Total Weight on Both Tires, lb.	Tire Equipment	
		Solids	Pneumatics		Solids	Pneumatics
¾	1500	.....	34x4½	3,200	.....	36x 6
1¼	2200	36x3½	35x5	4,800	36x6	38x 7
2	3000	36x4	36x6	7,000	36x7	40x 8
3½	4500	36x5	38x7	11,000	40x5D	44x10
5	5500	36x6	......	15,000	40x6D	......
7	7500	36x7	......	20,000	40x7D	......

Notes: Weights given include chassis, average heavy body and full rated load.
These figures apply irrespective of wheelbase.
Pay load uniformly distributed in body.

This simplification of sizes, according to the Commercial Economy Board, will conserve space in ship bottoms now wasted in the importation of excess crude rubber, utilize manufacturing facilities to the best advantage, and reduce capital invested in raw material and finished product; all these are aside from the advantages to the automobile users.

At a later meeting of the Tire and Rim Division, held at the Hotel Statler, Cleveland, on May 11, the matter outlined above was presented for action. Other topics discussed at that meeting were routine tests of rims, motorcycle tires, valve holes, rim sections, and wood spokes.

TABLE III—RANGE OF PNEUMATIC TIRE SIZES REQUIRED BY AMERICAN CARS BEING MANUFACTURED IN 1918

Rim Dia., In.	Tire Widths, In.							
	3	3½	4	4½	5	6	7	8
23		30x3½	31x4 ← fits	33x4½	32x5 ← fits			
24	30x3	31x3½ ← fits	32x4	33x4½ ← fits		36x6	38x7	40x8
25		32x3½	33x4 ← fits	34x4½	35x5 ← fits			
26			34x4	35x4½ ← fits		Note: A few 36x5½ tires not shown here are used on one car.		
27				36x4½	37x5 ← fits			

PROPOSED SIMPLIFIED SCHEDULE OF TIRE SIZES

Rim Dia., In. and Mm.	Tire Widths, In. and Mm.							
		3½-90	4-105	4½-120	5-135	6-150	7-175	8-200
23 / 585		30x3½	31x4 ← fits					
24 / 610						36x6	38x7	40x8
25 / 635		32x3½	33x4	34x4½	35x5 ← fits			

Explanation:—
Tires fitting the 23-in. rims are for Ford passenger cars.
Tires fitting the 24-in. rims are the sizes required by pneumatic-tired trucks.
Tires fitting the 25-in. rims are for all passenger cars other than Fords (or cars in the same class).

The report of Mr. Hale was referred to the Truck Division and to the truck manufacturers for their comments.

Routine Test of Rims

It was decided to change the third paragraph, Sheet 8f, Vol. I, S. A. E. Handbook, to read: "The deflection of a straight-side rim should be measured across the extreme width (dimension *H* in the drawing)." Also that the center figure showing clincher type be omitted and that the table be extended to include 6 and 7-in. straight-side rims. Mr. Tew was appointed to prepare the necessary data.

Pneumatic Tire Sizes for Passenger Cars

It was agreed that drawings showing rim sections and contours be added to S. A. E. Data Sheet 8g, in accordance with the recommended practice of the Tire and Rim Association.

Carrying Capacities and Inflation Pressures

It was recommended that the following be added to Data Sheet 8h:

Tire Width, In.	Max. Load, Lb.	Max. Inflation Press., Lb.
7	2700	100
8	3650	110

Motorcycle Tires

It was recommended that the Tire and Rim Association be asked for a recommendation as to inflation pressures and carrying capacities of motorcycle tires.

Valve Holes

It was recommended that the valve hole in motorcycle rims be 17/64 in. by ⅜ in., and that Mr. Jobski be appointed to investigate existing practice as to the valve-hole dimensions in automobile rims.

Rim Sections (Base Bands) for Solid Tires

A committee appointed to consider the advisability of standardizing base band dimensions for solid tires is as follows: J. E. Hale, W. H. Allen, H. W. Waite, E. G. Hulse and A. W. Venner.

Wood Spokes

Mr. Carlton was appointed to confer with the Automotive Wood Wheel Manufacturers' Association and make a report to the Tire and Rim Division on the subject of the standardization of wood-spoke dimensions.

Cooperation with Tire and Rim Association

A motion was made and carried that "it is the sense of this meeting that there should be closer cooperation and correlation of work between the Tire and Rim Division of the S. A. E. Standards Committee and the Tire and Rim Association, and to this end that the minutes of the meetings of each organization be exchanged.

"That at least three representatives from car manufacturers be added to the Tire and Rim Division in order that all work of the Tire and Rim Association be thoroughly discussed with a view of presenting its recommendations to the Standards Committee for adoption as S. A. E. standards."

DATA SHEET CORRECTION

In the letter accompanying the new data sheets mailed to the members last April, instructions were given for the cancellation of page 6-h of Volume I., S. A. E. Handbook. *Page 6-g of the same volume should be cancelled instead of page 6-h.* Upon request, another copy of page 6-h will be supplied to any member who has destroyed that page.

Activities of S. A. E. Sections

PLANS are now being developed to hold a Section Conference during the summer meeting. This will take place on the evening of June 16 at the Engineers' Club, Dayton. A number of subjects of broad interest to all the Sections will be discussed, and a general invitation is extended to the Section officers and to any members interested in Section work to attend. The administrative year of all sections now starts on May 1, and new officers have just started work, therefore, in all of them. It is hoped, however, that both the officers of last year and the officers now carrying on the Section work will attend the Conference, so that a concerted effort can be made to strengthen the Section movement during the coming fall and winter.

Buffalo Section.—The last meeting of the Buffalo Engineering Society at which the Buffalo Section of the S. A. E. presented an automotive engineering paper was held April 24 at the Hotel Statler. F. W. Gurney spoke on the design, manufacture, and application of ball bearings of the combined radial and thrust type. After his address there was considerable discussion as to the value of different types of bearings and as to the method of applying them.

On May 1, at the final meeting of the season of the Buffalo Engineering Society, David Fergusson, the retiring chairman of the Buffalo Section of the S. A. E., made a report covering the activities of his section during the past season. This report follows:

"The Society of Automotive Engineers Section had five meetings allotted to it by the Engineering Society of Buffalo, and at each of these meetings we had a good attendance.

"The policy of holding these meetings in conjunction with the other engineering sections has been proven an excellent one, due to the interest taken in these meetings by the members of the other sections. Had some of these meetings been reserved for S. A. E. members only, the attendance would have been so poor that it would have been rather embarrassing to both speaker and chairman.

"One of our meetings, a popular illustrated lecture on airplanes, was remarkably well attended. The other four meetings, however, were of more technical value. These were of real interest not only to automotive engineers, but to mechanical and electrical engineers also. The speakers were local men who are authorities on their subjects.

"I believe the greatest value of these local branches of the national engineering societies is in the bringing out of men who might otherwise rarely become known to the parent society. The honor that comes to the author of a good paper on a technical subject was shown especially in the case of one of our speakers. His paper was published in the *Transactions of the American Society of Mechanical Engineers* as well as in the S. A. E. TRANSACTIONS, also in several of the leading American automobile journals and in the leading English automobile journal. The favorable comments he has received have more than repaid him for the time and effort he put into the preparation of the paper.

"I believe the value of such meetings have been appreciated by those who desire to know more of the many branches of engineering that are represented by the membership of this section."

The officers of the Buffalo Section for the coming year are as follows: H. R. Corse, chairman; David Fergusson, vice-chairman; E. T. Larkin, secretary; and O. M. Burkhardt, treasurer.

Cleveland Section.—The April 19 meeting was devoted to a discussion of factory inspection. Walter C. Keys gave a very comprehensive talk on the meaning of the work of the inspector in the automotive industry. He illustrated his remarks on the different types of inspection such as visual, measuring, gaging, etc., by an account of his personal experience in doing such work. Capt. C. F. Cleaver of the British Army described the inspection required in buying military motor trucks. He emphasized the importance of paying more attention to assembling inspection, and also of having high-grade men to take charge of the work, since it involves dealing with responsible heads of factory organizations.

Some interesting ideas of a little different type of inspection were presented by Mr. Wells of the Peerless Motor Car Company, who has just returned from three years spent in England inspecting motor trucks after their long ocean voyage. He stated that the inspection at the factory on behalf of the customer should cover all ordinary tests, so that the inspection on the other side would relate only to troubles that might develop in transit. He showed the importance of packing in order to avoid trouble from salt water, giving several different instances in which the salt water had caused trouble after the trucks arrived in England. E. T. Birdsall related some of his experiences in the early days when it was possible to import French cars in which the gasoline was left in the tank so that they could be taken out of their crates and driven away.

A committee of tellers appointed by Chairman Strickland reported that the following officers were elected: Chairman, H. H. Newson; vice-chairman, S. G. Thompson; secretary, R. E. Clingan; and treasurer, R. S. Begg.

The May meeting of the Section was held on the 19th at the Hotel Statler. R. B. Lea of the Sperry Gyroscope Company gave a talk, illustrated by motion pictures and slides, and showing the practical applications of the gyroscope.

Detroit Section.—At the April 26 meeting of the Section, a paper on the history of the development of gun manufacture prepared by Lieut. W. Z. W. Skeritt and read by H. M. Jerome was given. This covered the manufacture of guns from the year 1314, when a gun for shooting darts was made at Ghent and sent to England. The development of modern artillery was considered at length, and a brief account presented of its manufacture.

The May meeting of the Section was held on the 24th, when Lee Anderson, vice-president Hupp Motor Car Corp., discussed the sales problems of the immediate future.

New officers were elected as follows: J. E. Schipper, chairman; A. C. Hamilton, vice-chairman; Don T. Hastings, treasurer; and C. F. Van Sicklen, secretary. R. E. Wells was elected as the section representative on the Society Nominating Committee.

Indiana Section.—A business meeting of the Section was held at Hotel Claypool, April 26, at which a number of matters relating to Section operation were considered. W. S. Reed was elected to represent the Section on the

Nominating Committe, which will meet at Dayton June 17 to select a ticket for the 1918 Society officers.

It was planned to hold the May meeting on the 24th and to have a paper presented on some up-to-date aircraft subject.

Metropolitan Section.—The Section gave its annual dinner to the Council on the evening of the 20th, the day when the regular monthly meeting of the Council was held at New York. President C. F. Kettering spoke of recent aviation progress with special reference to the Liberty aircraft engine. General Manager C. F. Clarkson and Councilor C. M. Manly, who have recently returned from Europe, discussed their experiences abroad in connection with the work of the American Aircraft Commission. Capt. B. C. Crossley, of the British War Mission, related some of his experiences in the British Army Service Corps in connection with motor trucks in war service. Several motion pictures of French aircraft in course of manufacture and in flight were shown.

The application of tractors to industrial service was discussed at the April 24 meeting, held at the Automobile Club of America. W. P. Kennedy explained the evolution through which these vehicles had passed, and showed how their use in industrial plants saved labor and in some cases permitted women to be used, by machines that almost paid for themselves by the saving made in short periods. B. R. Tewksbury showed a number of motion pictures of small tracklaying types of tractors and described their construction and operation.

The following officers were elected for the ensuing year: C. F. Scott, chairman; H. G. McComb, vice-chairman; R. Allerton, secretary; and A. C. Bergmann, treasurer.

Mid-West Section.—The following letter, dated March 16, 1918, from Edward S. Nethercut, secretary of the Western Society of Engineers, proposing an alliance of the technical societies of Chicago, was read at the March 22 meeting of the Section:

"We bring to your attention a situation, or condition, which in our judgment makes against the effectiveness, the influence, and the usefulness of technical men as a body; and we presume to offer a suggestion for cooperative action which we believe will go far toward correcting the deplorable condition which now obtains.

"Each technical organization has its incentive, its reason for existence, worthy, helpful and deserving of perpetuation. While this is true, there are movements actuated by causes which appeal with almost equal intensity to every technical organization, calls of patriotism to which every lover of his country feels a responsive thrill; calls of human interest, born of great calamities; calls for civic effort on behalf of moral or physical uplift.

"All of these and other questions are put up to the technical citizen as they are to every professional or nonprofessional member of the community.

"As matters now stand, our efforts lack that unity in which there is strength, and because of this lack of unity our real effectiveness is not felt.

"What we suggest is the formation of a technical alliance, represented by a board or committee, upon which there should be a representative from each technical organization in Chicago. This board shall select a chairman, vice-chairman and secretary. This board shall meet at stated intervals to consider questions of common interest; to devise ways and means of advancing the interests of technical men; arrange programs for carrying on such campaigns of patriotic service as come before the public from time to time, and to develop lines of work which will be for the public good or to increase the usefulness and enlarge the influence of technical men and their organizations.

"The board of direction of the Western Society of Engineers considers this an opportune time for such an alliance in view of the call now made on technical men in the prosecution of the war.

"We believe that we should have a conference of technical organizations to consider the suggestions made herein and we ask an expression of views from your organization at your early convenience."

By vote of the members of the Section, it was decided to enter this alliance, and F. E. Place was then elected to represent the Mid-West Section.

Col. L. D. Wildman, chief signal officer of the Central Department of the U. S. Army, next discussed the work of the different departments of the Signal Corps and the tremendous task which confronted them in expanding the army. He said the public, generally, did not know how much the Signal Corps embraced, what a large field it had to cover, and he hoped to get the aid and assistance of the automotive engineers of the country on problems which, although not directly connected, were in a certain sense allied with the work they were doing. He urged engineers to offer suggestions. Some of his remarks are quoted below:

"First among the activities of the Signal Corps is the activity in the air, which embraces the heavier-than-air and the lighter-than-air machines. In connection with these, of course, there is a tremendous amount of engineering. Each pilot has three airplanes—one machine which is flying, one ready to fly and the third which is being tuned up. Thirty-six men are required on the ground to keep those machines in proper condition for one man to do his work. About three-quarters of those men are technically trained. We must have wheelwrights, rubber vulcanizers for the tires, rope riggers, cabinetmakers, and so on through the whole list of technical trades. All transportation of airplanes and balloons is now done by motor truck, so we must have motor truck mechanicians on hand and in readiness to keep our transportation facilities in proper order.

"The second great division of the Signal Corps comprises the radio, telegraph and telephone activities. The Signal Corps is responsible for the manufacture, operation and maintenance of all the radio-telegraph stations on land. That means that we have stations of all sizes from those capable of sending messages thousands of miles, down to the pack set carried by a mule, the pack set being capable of sending news 15 or 20 miles. All the types are being used satisfactorily, which is proof of the engineering ability of the wireless people in this country and the ability of the Signal Corps privates and non-commissioned officers to use these sets with intelligence and discretion. Of all the enlisted men that I have ever seen in any other army in the world, the enlisted man in the United States Signal Corps stands out in a class by himself. We have men as privates in the Signal Corps today who were getting between $15,000 and $20,000 in their business as engineers; rather than go to Washington to get a commission they came in as privates and have worked up.

"When we had to raise 15,000 officers, examining boards were sent out to several of the large cities; these boards were made up of men of different characteristics. The papers from these boards were sent to Washington for examination, and Washington had to decide from these papers the grade and rank of the officer. Naturally, some mistakes were made. Signal Corps officers will be taken henceforth from the ranks, which is the only fair and

just way. Every private has a chance to become a commissioned officer.

"The next big division embraces the deep-sea cable work. Very few people know that the Signal Corps operates a deep-sea cable ship. The coast artillery requires a very comprehensive system of cables." Colonel Wildman then told of the extent of the system, the wonderful development of it, the work of the men, and the rapidity with which the work has to be handled.

The meeting concluded with a brief talk by William Lehle, president of the Commercial Motion Pictures Mfg. Co., on the employment of moving pictures as a medium for selling automotive products, and with motion pictures showing the manufacture of the Dodge car and uses of tractors in the field.

A report covering the work of the administrative year was received from the officers of the Mid-West Section and two technical papers were presented at the April 26 meeting. A paper prepared by H. T. Sward and read by Secretary D. S. Hatch described an oil-burning tractor engine, and J. G. Zimmerman gave a paper on Magneto Ignition for Farm Tractor Engines.

An announcement was made that the next meeting of the Section, to be held June 4 at the Hotel Sherman, will be a joint session with the National Gas Engine Association. In the afternoon papers by H. R. Van Deventer on the Mechanical Construction of Ignition Magnetos and by E. D. Blakely on the Hvid Engine and its Relation to Poppet Valve and Diesel Types will be given, while a Gas Engine Dinner will be held in the evening.

A report was presented regarding the election of officers as follows: George W. Smith, chairman; D. S. Hatch, secretary; Lon Smith, treasurer. C. S. Whitney and G. L. Lavery become members of the Governing Committee on account of their having been chairman and treasurer respectively during the past year.

Minneapolis Section.—The last meeting of the year was held May 1 at the Hotel Radisson, when a paper on the Resistance to Rolling of Tractor Wheels was presented by A. F. Moyer, Experimental Engineering Department, University of Minnesota. Mr. Moyer described the work that he has been doing during the past year in determining the factors that effect the rolling resistance of wheels on loosely packed soil. Before the technical part of the meeting at a dinner attended by nearly one hundred members, addresses were made by George M. Gillette on the duty of the individual in the present war, by Dean J. R. Allen, Engineering School, University of Minnesota, on the possibilities for American export business after the war, and by Field Secretary R. E. Plimpton of the Society, who described some of the current activities of the parent organization.

Pennsylvania Section.—An interesting talk on the use of tanks in modern war was given by Lieut. E. L. Kinder of the U. S. A. Tank Corps, at the April 26 meeting of the Section. He also described the methods of trench fighting developed in the present war.

Officers for the next year were elected as follows: Chairman, C. A. Musselman; vice-chairman, J. W. Watson; secretary, H. E. Rice; treasurer, W. M. Newkirk.

Chairman Musselman addressed the meeting on the possibilities for Section work during the coming year. The Government has made Philadelphia the largest machinery center in the world so that it will be the engineering center of the world. He advocated holding meetings in other parts of the State, and said that plans would be set on foot for greatly increasing the interest and membership in the Pennsylvania Section.

The annual outing of the Section was held on the afternoon of May 24, and consisted of a trip of inspection to the Hog Island Shipyard, with a dinner at the Hotel Adelphia in the evening. Among the speakers at the dinner were Councilor H. L. Horning, Wm. B. Stout and Harry Tipper. Congressman R. O. Moon of Pennsylvania will act as Toastmaster.

NEW WAR DEPARTMENT INVENTIONS BUREAU

In order to secure prompt and thorough investigation of inventions submitted to the War Department, an Inventions Section has been created as an agency within the General Staff.

Inventions may be sent by mail or may be submitted in person, accompanied by written descriptions or drawings. They go first to an examining board having technical knowledge of the classes of inventions they handle, whose investigations determine whether the inventions have merit. Those with merit are referred to the Advisory Board.

Composing the Advisory Board at present are the following: D. W. Brunton, member Naval Consulting Board and chairman War Committee of Technical Societies; Dr. Graham Edgar, member National Research Council; Col. James W. Furlow, Quartermaster Department, Chief of Motors Division; Col. J. A. Hornsby, M. C., Chief of Hospital Division, Surgeon General's Office; Lieut. Col. Morgan L. Brett, Ordnance Department, Engineering Branch; Lieut. Col. Robert A. Millikan, S. C., Chief of Science and Research Division; Lieut. Col. N. H. Slaughter, S. C., Chief of Radio Development Section; Major Joseph A. Mauborgne, S. C., Chief of Electrical Engineering Section.

In testing and developing inventions and in considering problems presented by staff departments, the Advisory Board works in connection with a number of agencies. Among them are the following: Research Council; Bureau of Standards; War Committee of National Technical Societies (this committee consists of two members detailed from each of ten important technical societies in the United States); laboratories and shops of the staff and supply departments of the Army; Patent Office; the Aircraft Board; all of the Army service schools; C. L. Norton, Massachusetts Institute of Technology, Cambridge, Mass.; Dr. Charles P. Steinmetz, General Electric Co., Schenectady, N. Y.; A. H. Beyer, chairman committee on testing laboratory, Columbia University, Broadway and One Hundred and Seventeenth Street, New York City; R. R. Abbott, metallurgist, Peerless Motor Car Co., Cleveland, Ohio; Dr. John A. Matthews, president Halcomb Steel Co., Syracuse, N. Y.; Knox Taylor, president Taylor-Wharton Iron & Steel Co., High Bridge, N. J.; Howard D. Colman, Barber-Colman Co., Rockford, Ill.; Preston S. Miller, Electrical Testing Laboratories, Eightieth Street and East End Avenue, New York City; Herbert Fisher Moore, University of Illinois, Urbana, Ill.; L. F. Miller, metallurgist, Mitchell Moore Co., 1832 Asylum Avenue, Racine, Wis.; E. J. Okey, the Timken Roller Bearing Co., Canton, Ohio; Dr. Ales Hrdlicka, curator division of physical anthropology, United States National Museum, Washington, D. C.

Any person desiring to submit an invention for consideration, test, sale, or development should do so by letter, giving in order the following information: Name and object of the invention; any claim for superiority or novelty; any results obtained by actual experiment; whether the invention is patented; whether remuneration is expected; whether the invention has been before any other agency; whether the writer is owner or agent; the number of enclosures with the letter. A written description and sketches or drawings of sufficient detail to afford a full understanding of the cases should also be submitted. Should the invention be an explosive or other chemical combination, the ingredients and processes of mixture should be stated.

The Inventions Section will not bear the expense of preparation of drawings and descriptions, nor advance funds for personal or traveling expenses of inventors.

Any matter submitted will be treated as confidential. The inventor will be notified of each step taken during the investigation of his invention. All communications should be addressed: Inventions Section, General Staff, Army War College, Washington, D. C.

REPORT OF THE APRIL COUNCIL MEETING

THE April meeting of the Council was held at Dayton, Ohio, on the 25th with the following present: President C. F. Kettering, First Vice-President David Beecroft, Second Vice-Presidents C. C. Hinkley and Dent Parrett, Councilors B. B. Bachman, H. L. Horning and C. M. Manly, and Secretary Coker F. Clarkson.

Plans for the June meeting of the Society, which is to be held on the 17th and 18th at Dayton, were discussed. Chairman Beecroft of the Meetings Committee reported that it was thought desirable to center the arrangements around the exhibits of automotive war apparatus, providing the necessary arrangements could be made with Government authorities.

It was voted to make the following transfers in grade of membership: From Associate to Member grade: Herbert C. Berry, R. J. Fitness, F. M. Holden, Clifford R. Rogers and Edward C. Sendelbach. From Junior to Member grade: Walter J. Rudolph, Wilbur H. Whinne and Selden T. Williams.

Applicants to the number of 57 were elected to membership in the Society, these being assigned to grades as follows: 22 Members, 20 Associate Members, 11 Junior Members, 1 Affiliate Member, 3 Student Enrollments.

The resignations of the following members were accepted: F. W. Galbraith, Jerome Kingsbury, Walter H. Miller and John C. Naughton.

A report was presented by Chairman Bachman of the Constitution Committee to the effect that a copy of the constitutional amendments proposed at the Annual Meeting of the Society, together with the comments of the Council as to its changes in the form of these amendments, had been sent to all the voting members of the Society.

It was the sense of the Council that non-members of the Society asked to cooperate with divisions or subdivisions of the Standards Committee should be asked to serve as and should be known as "conferees."

The following were approved for appointment to the Standards Committee with designation to the divisions noted: Aeronautic Division, F. G. Ericson.

Ball and Roller Bearings Division: F. G. Hughes, chairman; George R. Bott, W. L. Batt, W. C. Baker, T. V. Buckwalter, E. R. Carter, F. W. Gurney, F. M. Germaine, C. W. McKinley, W. S. Rogers and J. G. Weiss.

Iron and Steel Division: F. P. Gilligan, W. B. Hurley and Forrest E. Cardullo.

Motorcycle Division: Capt. F. C. Hecox, C. B. Franklin, H. L. Greene.

Nomenclature Division—Aeronautic: W. B. Stout, G. C. Loening, J. M. Schoonmaker, Jr.; Marine, W. S. Howard; Tractor, J. L. Mowry, Henry Farrington; Truck, Darwin S. Hatch; Foreign, A. L. Clayden, Lieut.-Col. H. W. Harms.

Springs Division: Ralph W. Brown, S. P. Hess, William M. Harty.

Tire and Rim Division: Ford Lawrence, J. G. Swain and three other members to be named.

Tractor Division: J. F. Max Patitz, L. W. Chase, A. F. Moyer, G. A. Young, Robert Hawley.

Truck Division: B. B. Bachman, chairman; E. E. Wemp, Ralph W. Austin, B. F. Wright, H. T. Thomas.

It is decided to reestablish the Non-Ferrous Metals and the Spline Fittings Divisions, the members of these to be announced later.

A number of additional subjects were assigned for consideration of the different divisions, these being as follows: Aeronautic Division: Bolts with threaded ends.

Ball and Roller Bearings Division: Taper roller bearings, tolerances for aircraft ball bearings, metric size ball and roller bearings, magneto-type ball bearings.

Electrical Equipment Division: Starter motor mounting, sleeve-type starting motor and generator mounting, starting motor flange for large engines, mounting dimensions of gages and electrical instruments, non-magnetic shims for magneto mounting, flexible disks for magneto coupling (this work to be done in cooperation with the Engine Division and not to include couplings for aeronautic service).

Engine Division: Tolerance and keyway for magneto drive-shaft, flywheel housing for tractor engines, thermostat connections.

Iron and Steel Division: Screw stock specifications.

Miscellaneous Division: Bolt head and nut tolerances.

Tire and Rim Division: Solid rubber tire section contour, rim section contour for solid rubber tires, pneumatic tire sizes, motorcycle tire capacity and inflation pressure, wood spokes, sizes and capacity of truck tires.

Transmission Division: Companion flange for universal joints.

Spline Fittings Division: Review of spline fittings.

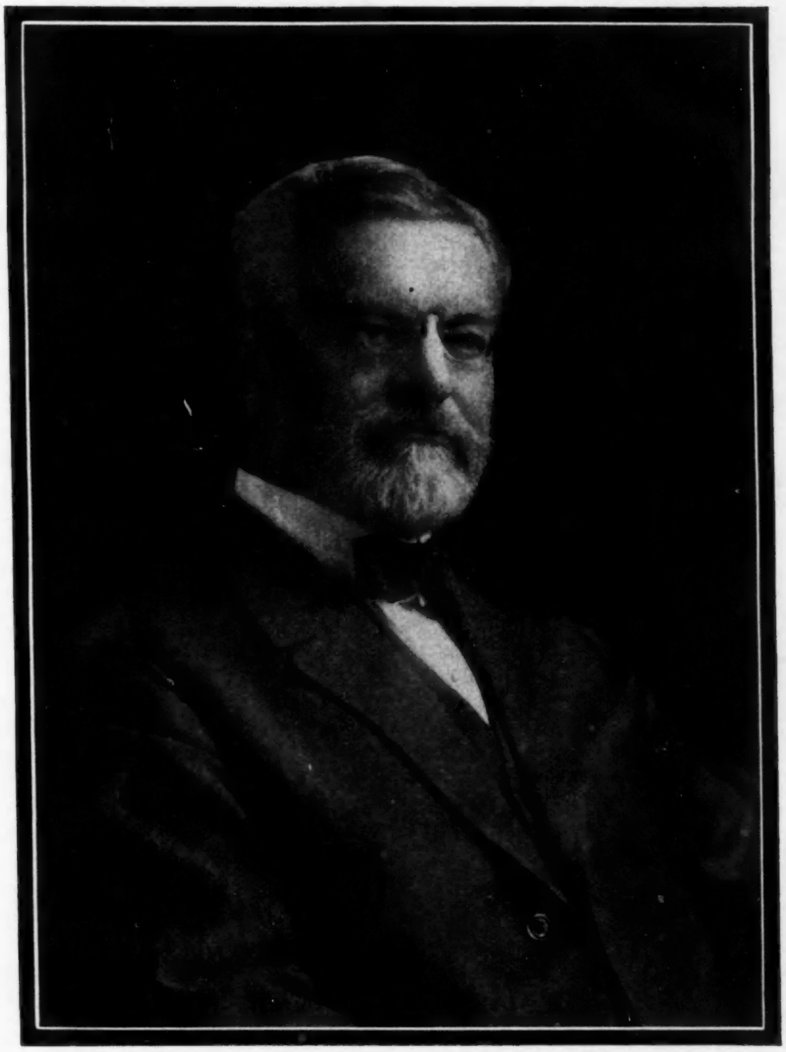
Non-Ferrous Metals Division: Bronze bearing metals, review of alloys containing tin.

Secretary Clarkson made a brief report of the work done by the Society's representatives at the recent International Aircraft and Screw Threads Standards Conference held in London during March and April. He said that it was planned to hold further conferences of a similar nature and that a tentative arrangement had been made looking to the organization of sections of the society in Paris and in London.

The next meeting of the Council will be held May 20 in New York. In the evening the members of the Council are invited to attend a dinner to be given them by the Metropolitan Section of the Society.

Frederick Remsen Hutton

HE was "one of the earliest engineers to take up the motor vehicle for his own use and as a professional activity." Thus Professor Hutton referred to himself and to one of his many interests. His sudden death at New York on May 14 was a distressing shock to all his friends among the members. It was a great loss to the Society, in which he had been a member and active worker since 1908.



It is given to few men to cover so many fields of activity and cover them so thoroughly as did Professor Hutton. As a consulting engineer, engineering professor, author of many engineering textbooks and articles, engineering society executive, many of these vocations being carried on simultaneously, he filled a long and useful life.

Born in New York May 28, 1853, he received his early education at a private school in that city and then entered Columbia College, where in 1873 he received the degree of bachelor of arts. Then he took the course at the School of Mines, being graduated there in 1876 as a mechanical engineer. His employment at the School a year later as instructor in mechanical engineering was said to mark the first recognition that Columbia gave to the important relation of mechanical engineering to other engineering courses.

In 1892 Professor Hutton was made professor in charge of the mechanical engineering department of Columbia University, and continued in this capacity until the time of his resignation in 1907, when he was elected professor emeritus. From 1899 to 1905 he was Dean of the Faculty of Engineering at Columbia. This institution in 1882 conferred upon him the degree of doctor of philosophy, following this with a degree of doctor of science in 1904, on the occasion of its one hundred and fiftieth anniversary.

For a quarter of a century Professor Hutton was an officer of the American Society of Mechanical Engineers, serving as secretary from 1883 to 1906, and as president in 1907. During his term of office the A. S. M. E. membership increased from about 300 to over 3500. The Engineering Societies building at 29 West Thirty-ninth Street was completed in this period. After the termination of his presidency of the A. S. M. E., he was elected honorary secretary, retaining this office until the time of his death. Perhaps his last important work with the A. S. M. E. was the preparation of a history of the Society, which covers the years from 1880 to 1915. During the whole of this time Professor Hutton was connected intimately with the A. S. M. E. work.

On retiring as president of the A. S. M. E., Professor Hutton made an address on the functions of an engineering society, developing in this the thesis that the historic definition of an engineer by Tredgold should be expanded to cover new functions of the profession that were not before the mind of the originator. The engineer, Professor Hutton pointed out, had become an economic factor, which he was not conceived to be in earlier days; in addition to his applying the powers of nature, he must also be considered as making use of the forces that are economic, social, or psychological in their application, since human beings have become the organs and implements of the factory as a tool of production.

Professor Hutton did his first consulting engineering work in 1878 and in later years continued it to a limited extent. In 1911 he served as consulting mechanical engineer to the Department of Water, Gas and Electricity in the city of New York. Soon afterward he became chairman of the Technical Committee of the Automobile Club of America, a position he held until his death. In this capacity he directed the laboratory work in the Club.

As a writer on technical subjects, Professor Hutton prepared many articles and books of merit.

His textbooks on "Mechanical Engineering of Steam Power Plants" (1897), on "Heat and Heat Engines" (1899), and on "The Gas Engine" (1903), are regarded as authorities in their fields. He did considerable work on technical terminology, collaborating with the publish-

ers of the Century dictionary, and of the International Encyclopedia. He also contributed a number of articles to automobile periodicals and scientific and engineering magazines.

Professor Hutton was elected a member of the Society on Feb. 1, 1908. He served as First Vice-president in 1915 and as a member of the Library, Papers, and Publication Committees from 1910 to 1915. In 1911 he was a member of the Nominating Committee of the Society. During 1915 and 1916 he was on the Research Division of the Standards Committee, which at that time was formulating important tests for measuring automobile fuel consumption and acceleration.

Just recently he was made chairman of the Nomenclature Division and had assumed the duties with his usual enthusiasm. His last work for the Society was done just a few days before his death, when as a member of its House Committee he spent some time in studying plans for new office arrangements.

In the passing of Professor Hutton the Society has lost a most highly valued friend and wise counselor. He never failed to do effective work when his service was enlisted.

AERONAUTIC NAVIGATING INSTRUMENTS

BEFORE an airplane can be put into military service it must be equipped with nine or more delicate aeronautic instruments, some of which are absolutely essential to exact flying, and all of which contribute to the successful operation of a plane. Without them a pilot would soon lose his location as to height and direction; he would not know his speed through the air, the speed of the propeller, the amount of gasoline in the tank, the cooling water temperature, or whether the oil is circulating. He could not be sure of banking properly on his turns. These comprise the necessary flying instruments, but an aviator could not fly to any great height without another valuable instrument, an oxygen-supplying apparatus, nor could he operate his guns, signal headquarters, release his bombs, or "shoot" his cameras without additional mechanisms.

Two Sets Sometimes Necessary

All these instruments must be ready for installation on the airplanes as soon as they are assembled, for no plane is complete without them. In some instances, particularly for the two-seaters and the heavy bombing machines, two and even three instruments of each sort are necessary, totaling sometimes as many as twenty-three, but for ordinary work only about nine of them are needed. The average cost of a set of navigation instruments for a single plane is $350.

For operation of actual combat planes, such as observing, photographing, bombing, and fighting planes, many other complicated and expensive instruments and sets of apparatus are necessary. Among them are machine guns, gun mounts, synchronizers, bomb racks, bomb-dropping devices, bomb sights, radio, photographic, and oxygen apparatus, electrically heated clothing, lights, and flares. The cost of such additional accessories would bring the total cost of equipment for a plane to several thousand dollars, depending upon its type.

One Purchasing Center

The Signal Corps is purchasing practically all the purely navigating instruments and selling them at cost to the manufacturers of the airplanes as they are needed to meet the actual output of planes. This provides one purchasing center and prevents the various airplane companies and the Government from competing against one another, creating disorder and confusion among the instrument manufacturers. At the same time it enables the Signal Corps to keep the supply of instruments adequate for the demands of the airplane builders, relieving them from this work, and it also affords standard equipment and interchangeability.

From an announcement of the Signal Corps, U. S. Army.

Foreign Models Improved

When the American air program began to be developed none of the instruments now so vital to the service was being produced in quantities, and some of them were not being produced at all. Over 60 per cent of these instruments had to be developed from foreign models, and the remaining 40 per cent was secured by modifying or remodeling American automobile-type instruments. Numerous and serious difficulties were encountered in designing instruments capable of quantity production, of the lightest possible weight and under exacting requirements as to accuracy. During this pioneer work new instruments were being developed abroad almost daily, each new design carrying an improvement.

Most of the work in this connection was done by the Signal Corps in conjunction with manufacturers. All available information and data were collected, foreign and domestic models and types were carefully tested, designs were standardized, and specifications prepared. Results show that types for every class of instruments have been adopted and put into production here. Far greater standardization has been reached than exists in Europe today, tending to increase quantity production materially and decrease the number of replacement parts necessary.

New Sources of Supply

Quantity production on the scale necessary demanded the enlargement of all existing sources of supply and the creation of many new plants and factories. A certain amount of time was available before it was necessary to use these instruments on planes in service—the planes themselves had to be built. Accordingly, orders were placed from three to eight months ahead of requirements, but only in such quantities as would insure a steady production, owing to the certainty of improvements in the various designs.

The early plans of the production department have developed from two to five sources for each instrument, established both as a safety measure and as a means of placing future orders on a strictly competitive basis.

Some Instruments Developed by Signal Corps

The tachometer, or revolution counter, is an instrument which indicates the number of revolutions per min-

ute at which the engine is running. Unlike the speedometer on an automobile, it does not translate revolutions into miles per hour; another instrument gives the speed in relation to the air. When instrument matters were taken up last July there were no tachometers manufactured in this country of the type which has proven most successful abroad; namely, the escapement or chromatic type. Two large manufacturing companies are now turning out these instruments in large quantites, one of them 100 a day, and a third company has also in production a new centrifugal type.

Air Speed Indicator

The air speed indicator is a pressure gage for showing the speed of the plane in relation to the air, not the earth. This instrument includes what is known as a venturi-pitot tube, which is fastened to a strut and takes in the air from ahead. The air sets up a corresponding pressure in an auxiliary tube, which is calibrated and indicated on a dashboard recording pressure gage.

The altimeter is an aneroid barometer, graduated to read height above the earth instead of pressure. Under standard specifications a reduction in weight and size was effected in the manufacture of these instruments, which are now being produced in large quantities and of a qualtiy equal to the best foreign instruments. Three standard types are made, with ranges of 20,000, 25,000 and 30,000 feet. Production was up to 500 a week in April.

Airplane Compass

A new type, having advantages over any present form of compass, especially as to compactness, is now used. In the development of this instrument effort has been made to reduce the weight to the safest possible minimum and to decrease the space required in the airplane. One company is now turning out compasses at the rate of 200 a week.

Airplane Clocks

As a result of the development which had been made in clocks for automobiles, it was only necessary to standardize a design of mounting in order to adapt such clocks to airplanes. Sufficient quantities are now available for all needs.

Pressure Gages

Instrument board pressure gages were already manufactured in this country in large quantities, and as soon as standard specifications were developed production started. Two types are used, one to register the air pressure which forces the gasoline to the engine and the other to show the pressure produced in the oiling system by the oil-circulating pump. Standard forms of cases and dials with interchangeable glasses and bezels have been designed.

Radiator Thermometer

The radiator thermometer is mounted on the instrument board, where it indicates the temperature of the cooling water in the engine. Undue heating shows that the engine is not running properly or that more water is needed. Thermometers of this type made here were, and still are, being submitted to extensive tests. Efforts were also made to stimulate the trade toward developing more accurate and reliable instruments, and now a sufficient supply is available from two sources.

Banking Indicator

The banking indicator is an instrument used to show when a plane is correctly banked in making a turn. Spirit level, balance, and gyroscopic types are being used. The problem of indicating the extent to which a plane is inclined to the horizontal in the air is a very complicated one. No simple solution has yet been reached. Fortunately, it is not often necessary to determine whether the plane is exactly horizontal, except in connection with bomb dropping. Development work is under way which it is hoped will lead to improvement of devices already in use abroad.

Aldis Sight

The Aldis sight, which is used in connection with fixed guns firing through the propeller, has been copied, as regards its optical features, from an English instrument; but the construction has been modified in such a way that the behavior of the instrument in actual use will probably be very much improved. After a number of tests and experiments satisfactory instruments are now available. The makers have been assisted in recomputing the lenses to suit the optical glass available in this country. The illumination of these sights for night operation is also being studied.

Standardization of Parts

In connection with the design of the above instruments it has been found possible, without delaying production, to standardize them to a much greater extent than has been done abroad. In this way the number of necessary replacement of parts has been considerably reduced, and a uniform type of dial has been adopted which, as to legibility, will be equal to the best that has so far been used. All finished instruments are carefully tested before being mounted on the planes.

Among other things, safety belts for pilots, observers, and gunners have been designed and are now in production; radio and photographic apparatus, ordnance devices, and oxygen apparatus have also been developed and put in course of manufacture.

Honor Roll of Society Members

THE following members have recently entered the services of the government in civilian or military capacities. This list, together with the "Service Directory of Members" following, is intended to contain the names of all members connected with the government, either in the military service or in civilian capacities. In both the "Honor Roll" and the "Service Directory" the names are listed in two parts, the first showing the members who have actually entered the military services, and the second those engaged as civilians. Every effort is made to have the addresses correct, but many of the members are changing about so much that it is almost impossible to tell accurately as to just where they are located at any given time. It is therefore requested, in case of any error, that the member concerned immediately inform the New York office of the Society, so that a proper correction can be made. Members who have actually entered the service in any capacity, and who are not listed, should also write the details to the New York office.

MILITARY HONOR ROLL

Alter, Arthur S., chief machinist's mate, U. S. N. R. F., Washington.

Anderson, Oscar G., private, Co. A, 1st Prov. Ordnance Depot Battalion, U. S. A., (mail) P. O. No. 713, A. E. F.

Baker, Francis H., chief machinist's mate, U. S. N. R. F., U. S. Naval Gas Engine School, Columbia University, New York.

Barnaby, R. S., ensign, U. S. N. R. F. C., Buffalo, assigned to inspection duty.

Bevin, Sydney B., captain, Engineering Bureau, Motor Equipment Section, Ordnance Department, U. S. R., Washington.

Billings, C. M., first lieutenant, Ordnance Department, U. S. A., Rock Island, Ill.

Blair, C. A., corporal, 472nd Aero Squadron, A. E. F., France.

Brandmeier, F. M., Signal Corps, U. S. A., Motor Transport School, Wilbur Wright Field, Fairfield, Ohio.

Briscoe, Frank, captain, Signal Corps, U. S. A., France.

Brodie, James S., Engineer Corps, U. S. N. A., Washington.

Clarke, A. Fielder, Ground School, Aviation Section, U. S. N., Washington.

Cleaver, Charles F., captain, A. S. C., British War Department, London, Eng., assigned as inspector of mechanical transport, (mail) Peerless Motor Car Co., Cleveland.

Comstock, Herbert F., cadet, Aviation Section, Signal Corps, A. E. F., (mail) 16th Foreign Detachment, A. P. O. 725, via New York.

Evans, Gordon M., captain, Engineering Bureau, Motor Equipment Section, Ordnance Department, U. S. R., Washington.

Gibbs, S. E., U. S. School of Military Aeronautics, University of Illinois.

Jenks, Weston M., U. S. N. R. F., Massachusetts Institute of Technology, Cambridge, Mass., assigned as instructor in naval aviation.

Jones, R. E., lieutenant, U. S. N. R. F., Washington, (mail) U. S. S. New York, Postmaster, New York City.

Junk, Fred H., second lieutenant, Aviation Section, Signal R. C., U. S. A. (mail) Signal Corps Aviation School, Carlstrom Field, Arcadia, Florida.

Klockau, W. F., private, Co. N., 4th Battalion, 163rd Depot Brigade, Camp Dodge, Iowa.

Levy, Alfred K., 3rd Ordnance Corps, assigned to Motor Equipment Section, U. S. N. A., Washington.

Loeb, S. Arthur, lieutenant, Signal R. C., U. S. A., (mail) General Motors Corp., Buick Division, Flint, Mich.

Ludolph, F. E., Aviation Section, Signal Corps, U. S. A., Kelly Field No. 1, S. San Antonio, Tex.

Meder, Charles, 2nd Regiment, Co. 10, Section 1, Aviation Section, U. S. Naval Training Station, Charleston, S. C.

Metcalf, George R., Jr., captain, Ordnance Department, U. S. N. A., Washington.

Michel, C. A., The Naval Auxiliary, Reserve Officers' Training School, Steamer J. H. Sheadle, Detroit River Station.

Morriss, Percy G. B., Naval Aviation Corps, U. S. Navy, Washington, (mail) Aviation Headquarters, Great Lakes Naval Station, Great Lakes, Ill.

O'Brien, Wm. B., Jr., cadet, School of Military Aeronautics, Barracks No. 1 Champaign, Ill.

Ogren, Carl F., chief machinist's mate, Ordnance Inspection Department, U. S. N. R. F., Washington.

Ong, D. G., first lieutenant, Aviation Section, Signal Reserve Corps, U. S. A., Dayton, Ohio.

Osborne, Arthur D., second lieutenant, Ordnance R. C., U. S. A., Washington.

Pechnick, Frank J., 31st Balloon Co., U. S. A., Post Field, Ft. Sill, Okla.

Pickard, Lynn W., chief machinist's mate, U. S. Naval Air Service, A. E. F., France.

Pratt, Jesse T., first lieutenant, Aviation Section, Signal Corps, U. S. A., Washington.

Richardson, F. E., private, Engineer R. C., U. S. A., Washington.

Rifkin, G., sergeant, inspector, Military Truck Production Division, Quartermaster Corps, U. S. N. A., (mail) Covert Gear Works, Lockport, N. Y.

Schupp, Arthur A., second lieutenant, Aviation Section, Engineering Department, New York Equipment District, Signal Corps, U. S. A., Washington.

Sloane, John E., first lieutenant, aeronautical engineer, Aviation Section, Signal Corps, U. S. A., Washington.

Smith, Westcott T., second lieutenant, Engineering Department, Aviation Section, Signal R. C., U. S. A., Chaunte Field, Rantoul, Ill.

Sperry, Lawrence B., ensign, U. S. N. R. F., Massapequa, N. Y.

Stalb, A. Rolstan, ensign, U. S. N. R. F., (mail) Office of Operations, Aviation, Navy Annex, Washington.

Strauss, M. Frank, first lieutenant, 307th Mobile Ordnance Repair Shop, 82nd Division, U. S. A., Camp Gordon, Ga.

Streicher, George A., lieutenant, 3rd Engineers' Training Regiment, Camp Humphrey, Va.

Tyler, O. P., captain, Ordnance R. C., U. S. A., Rock Island, Ill.

Watson, C. Roy, lieutenant, Aviation Section, Signal R. C., U. S. A., Washington.

Weeks, Paul, captain, Ordnance Department, U. S. A., Washington.

Wilson, H. C., major, 58th U. S. Artillery, Coast Artillery Corps, Ft. Schuyler, N. Y.

Wood, Frank B., captain, technical expert, Air Division, Signal R. C., U. S. A., Washington, (mail) 3rd Motor Mechanics Regiment, Camp Greene, Charlotte, N. C.

CIVILIAN HONOR ROLL

Adams, Ralph L., Quartermaster Corps, U. S. A., Washington, assigned to Engineering Section, Motors Division.

Blakemore, Thomas L., aeronautical engineer, Bureau of Construction & Repair, U. S. N., Washington.

Brewer, Robert W. A., inspector of mechanical transports, British Army, London, Eng., (mail) Holt Mfg. Co., Stockton, Cal.

Bubna, Richard C., designer, Engineering Office, Motor Transport Division, Quartermaster Corps, U. S. A., (mail) Room 305 Union Station, Washington.

Creager, F. L., in charge of electrical equipment tests, engineering laboratory, Motor Transportation Section, Quartermaster Corps, U. S., (mail) N. A., Room 205 Union Station, Washington.

Dresser, L. W., mechanical engineer, Motor Transportation Division, Engineering Section, Quartermaster Corps, U. S. A., (mail) Room 306 Union Station, Washington.

Frehse, A. W., engineer, Quartermaster Corps, U. S. A., Washington, assigned to Engineering Section, Motor Transport Division.

French, H. J., senior inspector, Pittsburgh District, Aviation Section, Signal Corps, U. S. A., Philadelphia, assigned to Inspection Department.

Flogaus, H. A., designer and checker, Motor Transport Engineering Division, U. S. A., (mail) Office of Quartermaster General, 205 Union Station, Washington.

Gibson, Hugo, automotive purchasing, British War Mission, New York.

Harrigan, F. P., aeronautical engineer, Equipment Division, Airplane Engineering Department, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Hart, Frank S., designer, Engineering Section, Motor Transportation Division, Quartermaster Corps, U. S. A., Washington.

Hicks, H. A., aeronautical engineer, Equipment Section, Aviation Section, Signal Corps, U. S. A., (mail) Major E. J. Hall, Lindsey Building, Dayton, Ohio.

Hower, Henry M., production manager, New London Naval Base, New London, Conn.

Kingsbury, J. A., metallurgist, Aviation Section, Signal Corps, U. S. A., (mail) Trego Motors Corp., New Haven, Conn.

Leavell, R. A., Federal Board for Vocational Education, Washington, assigned as associate professor of mechanical engineering in charge of automobile instruction, Camp Joseph E. Johnston, Jacksonville, Fla.

Macpherson, James W., inspector of airplanes and airplane engines, Signal Service at Large, Signal Service, U. S. A., Washington.

MacDonald, K. B., consulting engineer, Naval Aircraft Factory, League Island, Philadelphia.

McDonald, E. G., aeronautical engineer, Airplane Engine Division, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Miller, C. S., automotive engineer, U. S. A., Washington; (mail) 1750 Ekin Ave., New Albany, Ind.

Randall, J. M., assistant inspector of ordnance, Ordnance Department, U. S. A., (mail) Nash Motors Co., Kenosha, Wis.

Rider, W. Keith, Signal Corps, U. S. A., Washington, assigned to Production Engineering Department.

Roberts, D. S., inspector of airplanes and airplane engines, Aviation Section, Signal Corps, U. S. A., (mail) Standard Aircraft Corp., Elizabeth, N. J.

Roberts, Samuel B., inspector of airplanes and airplane engines, Signal Service at Large, U. S. A., (mail) Sturtevant Aeroplane Co., Jamaica Plain, Mass.

Russell, L. L., Engineering Office, Motors Division, U. S. A., (mail) Office of Quartermaster General, 305 Union Station, Washington.

Shaw, B. Russell, Aviation Engineering Department, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Soulis, Wilbur T., mechanical engineer, United States Gas Defense Plant, Long Island City, N. Y.

Spragle, R. L., inspector, Detroit district, Signal Corps, U. S. A., Garfield Building, Detroit.

Thomas, T. R., mechanical engineer, Signal Corps, U. S. A., McCook Field, Dayton, Ohio.

Service Directory of Members

Military Service

Alden, Herbert W., lieutenant-colonel, Motor Equipment Section. Carriage Division, Ordnance R. C., *Washington*.

Aldrin, Edwin E., lieutenant, Coast Artillery Corps, U. S. A.. *Ft. McKinley, Maine*.

Amon, Carl H., first lieutenant, Aviation Section, Signal R. C., 1st Motor Mechanics' Regiment, A. E. F., *France*.

Anderson, Oscar G., private, 161st Depot Brigade, Co. 4, U. S. N. A., (mail) Barracks 1488W, Camp Grant, Ill.

Anderson, E. S., lieutenant, Aviation Section, Signal Corps, U. S. A., Rockwell Field, *San Diego, Cal.*

Anderson, William C., lieutenant, Engineer R. C., *Brooklyn, N. Y.*

Arnold, Bion J., lieutenant colonel, Aviation Section, Signal R. C., *Washington*.

Barker, C. Norman, pilot cadet, Royal Flying Corps, *Camp Borden, Can.*

Barton, W. E., first lieutenant, Quartermaster R. C., *Washington*.

Bates, Wm. O., Jr., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington*.

Bibb, John T., Jr., lieutenant, Aviation Section, S. R. C., Love Field, *Dallas, Texas*.

Blank, M. H., first lieutenant, Motor Equipment Division, Ordnance R. C., Grant Motor Car Co., *Cleveland*.

Blood, Howard E., captain, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned as business executive, Airplane Engineering Department.

Boggs, Geo. A., lieutenant, Quartermaster Corps, U. S. A.; (mail) Farmers Loan & Trust Co., *Paris, France*.

Bowen, C. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington*.

Britten, Daniel L., captain, Ordnance R. C., *Washington*, assigned to Gun Division, Ordnance Section.

Britten, Wm. M., major, engineer of motor transportation, Quartermaster R. C., *Washington*.

Brown, Harold Haskell, first lieutenant, Coast Artillery Corps, U. S. N. A., *Fort Totten, N. Y.*

Browne, Arthur B., captain, Sanitary Corps, U. S. N. A., (mail) General Motors Co., *Detroit*.

Callan, John Lansing, lieutenant, Reserve Flying Corps, U. S. N., U. S. S. Seattle, (mail) Postmaster, *New York*.

Campbell, Archibald F., Aviation Section, Signal R. C., *Washington*.

Campbell, Lindsey F., 4th Battery, 2d P. T. R., *Fort Sheridan, Ill*

Chase, A. M., major, Ordnance Department, U. S. A., *Washington*.

Clark, Edward L., first lieutenant, Signal R. C., McCook Field, *Dayton, Ohio*.

Clark, Elmer J., captain, Signal R. C., *Buffalo, N. Y.*

Clark, Virginius E., lieutenant colonel, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*.

Coe, Edw. M., first lieutenant, Quartermaster Corps, U. S. A., *Washington*, (mail) Mechanical Repair Shops No. 302, A. E. F., *France*.

Cockrill, Emmet, first lieutenant, Ordnance R. C., Ford Motor Co., *Highland Park, Mich.*, assigned as production officer and mechanical engineer.

Coffman, Don M., first lieutenant, Aviation Section, Signal R. C., Commercial Bldg., *Dayton, Ohio*.

Collins, Kenneth G., first lieutenant, Signal R. C., A. E. F., *Italy*, (mail) 8th Aviation Instruction Center.

Dahlquist, Chas. S., major, Quartermaster Department, U. S. N. A., *Washington*, assigned to Motors Division as supervisor of inspection on standardized military trucks.

Dayton, William E., private, 306th Regiment, Field Artillery, U. S. N. A., *Washington*.

Deeds, Edward A., colonel, Equipment Division, Signal Corps, U. S. A., State, War and Navy Bldg., *Washington*.

Denison, Arthur H., cadet, School of Military Aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

De Lorenzi, Ernest A., officer, Mechanical Transport, War Department, *London, Eng.*

De Witt, George W., ensign, U. S. N., *France*, (mail) U. S. S. Utowana, Postmaster, *New York.*

Diamond, James E., captain, Ordnance R. C., assigned to Motor Instruction School, *Kenosha, Wis.*

Dickey, Herbert L., captain, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

Dimond, G. A., first lieutenant, Motor Section, Ordnance R. C., Ft. Herring, *Peoria, Ill.*

Donaldson, Frank A., captain, Carriage Division, Ordnance R. C., Sixth and B Sts., *Washington.*

Dost, Charles O., first lieutenant, Aviation Section, Signal Corps, U. S. A., Ellington Field, *Houston, Texas*, assigned to engineering department.

Du Bose, Geo. W. P., major, American Ordnance Base Depot, A. E. F., *France.*

Duncan, A. C., first lieutenant, Balloon Co. No. 7, Signal Corps, Aviation Section, Signal R. C., (mail) A. E. F., *France.*

Duntley, Lloyd B., first lieutenant, Ordnance R. C., *Washington*, assigned to Engineering Motor Equipment Section.

Earle, Lawrence H., captain, Ordnance R. C., assigned as inspector of ordnance, Holt Mfg. Co., *Peoria, Ill.*

Eells, Paul W., lieutenant, 330th Field Artillery, Artillery R. C., Camp Custer, *Battle Creek, Mich.*

Engesser, Benj. M., School of Military Aeronautics, Massachusetts Institute of Technology, *Cambridge, Mass.*

English, G. H., Jr., first lieutenant, Ordnance R. C., *Washington.*

Farrell, Matthew, captain, Quartermaster R. C., *Washington.*

Finkenstaedt, Edward R., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Fishleigh, W. T., major, Sanitary Corps, U. S. N. A., *Washington*, assigned as automobile engineer.

Fitzgerald, Gerald, second lieutenant, Motor Truck Co. 348, Camp McArthur, *Texas.*

Flanigan, E. B., Officers' Reserve Training Camp, *Plattsburg, N. Y.*

Forrer, J. D., captain, Engineer R. C., *Washington.*

Foss, Clarence M., captain, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.

Foster, William J., second lieutenant, Signal R. C., U. S. A., *Washington*, assigned to Engine Design Section, Airplane Engineering Department, Aviation Section.

Fox, Rudolph H., first lieutenant, Ordnance R. C., *Washington.*

Franklin, G. King, captain, Motor Section, Ordnance R. C., *Washington.*

Fulton, Richard Wallace, 5th Cadet Squadron, Aviation Section, Signal Corps, U. S. A., *Houston, Texas.*

Furlow, James W., lieutenant colonel, Quartermaster Corps, U. S. A., *Washington*, assigned to Office of Quartermaster General.

Gaebelein, Arno W., lieutenant, Ordnance R. C., *Washington*, assigned to Carriage Division.

Gardner, Lester D., captain, 117th Aero Squadron, Signal Corps, U. S. A., *Washington.*

Getschman, G. F., second lieutenant, Ordnance R. C., *Washington*, (mail) Office of Inspector of Ordnance, Maxwell Motor Co., Chalmers Plant, *Detroit.*

Gey, William, 377th Truck Train, U. S. N. A., Camp Merritt, *Tenafly, N. J.*

Gfroerer, A. H., first lieutenant, Ordnance R. C., assigned as production officer, Maxwell Motor Co., Chalmers Motor Car Co., *Detroit.*

Gillis, Harry A., major, Ordnance R. C., *Washington.*

Glover, F. S., major, Ordnance R. C., *Washington.*

Gorrell, Edgar S., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., *Washington*, (mail) Air Service, A. E. F., *France.*

Graham, Louis, captain, 309th Engineers, Engineers R. C., *Camp Zachary Taylor, Ky.*

Gray, B. D., major, chief of production engineering department, Equipment Division, Aviation Section, Signal Corps, U. S. A., *Washington.*

Gray, Samuel W., first lieutenant, Aviation Section, Signal R. C., U. S. A., (mail) 4th Co., 2d Motor Mechanics Regiment, Air Service A. E. F., *France.*

Green, Geo. A., major, Tank Section, British E. F., *France.*

Guthrie, James, major, Ordnance R. C., *Washington*, assigned to Carriage Division, Engineering Bureau.

Haeske, F. C., lieutenant, U. S. A., Camp Sherman, *Chillicothe, Ohio.*

Hall, C. M., major, Aviation Section, Signal Corps, U. S. A., *Dayton, Ohio.*

Hall, Elbert J., major, Engine Design Section, Engineering Division, Signal Corps, U. S. A., *Washington.*

Hall, Richard H., Jr., first lieutenant, Quartermaster Corps, U. S. N. A., *Washington.*

Harms, Henry W., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., (mail) Base Section No. 3, *London, England.*

Hartman, A. A., private, U. S. N. A., Camp Devens, *Ayer, Mass.*

Hawke, Clarence E., Aviation Section, Signal Corps, U. S. A., *Washington.*

Hecox, F. C., captain, Quartermaster Corps, U. S. A., *Washington*, assigned to Engineering Bureau, Motor Division, in charge of standardization of military motorcycles.

Hegeman, Harry A., major, Quartermaster Corps, U. S. A., *Washington*, assigned to office of Officer in Charge of Transportation.

Henderson, S. W., first lieutenant, Ordnance R. C., *Washington.*

Hobbs, J. W., first lieutenant, Ordnance R. C., U. S. A., (mail) Holt Mfg. Co., *Peoria, Ill.*

Hoffman, Roscoe C., captain, Carriage Division, Motor Equipment Section, Ordnance R. C., *Washington.*

Horine, M. C., second lieutenant, Aviation Section, Signal R. C., *Washington.*

Horner, Leonard S., major, Equipment Division, Signal Corps, U. S. A., *Washington.*

Howard, Walter S., first lieutenant, Military Truck Production Section, office of Quartermaster General, *Washington.*

Houston, Harold S., 3d Officers' Training Camp, *Fort Monroe, Va.*

Hoyt, F. R., lieutenant, Aviation Section, Signal R. C., A. E. F., *France.*

Hubbell, Lindley D., lieutenant colonel, U. S. N. A., Ordnance Department, *Springfield, Mass.*, assigned as Officer in Charge, Hill Shops, Springfield Armory.

Hull, M. Lair, private, Ordnance Department, U. S. A., *Washington*, assigned to Trench Warfare Unit, Requirement Section, Control Bureau.

Jaco, E. L., captain, Engineer R. C., U. S. A., *Washington*, assigned to General Engineering Depots.

Jeffrey, Max L., first lieutenant, Military Truck Production Section, Office of Quartermaster General, *Washington.*

Jennings, J. J., first lieutenant, Engineer R. C., Office of Chief Engineer, A. E. F., P. O. 717.

Joy, Henry B., lieutenant colonel, 4th Motor Mechanics Regiment, Signal Corps, U. S. A., *Camp Hancock, Ga.*

Kalb, Lewis P., major, Quartermaster Corps, U. S. N. A., *Washington.*

Kendrick, John F., Signal Corps, A. E. F., *France*, assigned to Research Inspection Division.

Kennedy, H. H., lieutenant, Ordnance Department, U. S. A., *Washington*, assigned as inspector of ordnance.

Klemin, Alexander, sergeant, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*; assigned to research, Airplane Engineering Department, Aviation Section.

Kline, H. J., first lieutenant, Ordnance R. C., *Washington*, assigned to Anti-Aircraft Section, Carriage Division.

Kohr, Robert F., second lieutenant, Engineers R. C., *Washington.*

Kottnauer, Edwin H., first lieutenant, inspector of ordnance, Ordnance R. C., U. S. A., (mail) Paige-Detroit Motor Car Co., *Detroit.*

Lane, Abbott A., first lieutenant, Aviation Section, Signal R. C., *Detroit, Mich.*

Lanza, Manfred, major, Quartermaster Corps, U. S. A., 303rd Motor Supply Train, Camp Dix, *Wrightstown, N. J.*

Larsen, Lester Reginald, second lieutenant, 107th Engineer Train, U. S. A., A. E. F., *France.*

Lavery, Geo. L., Jr., first lieutenant, Ordnance R. C., *Washington.*

Lay, Arthur J., captain, Aviation Section, Signal R. C., *Washington.*

Le Fevre, Wm. G., lieutenant, Train, 77th Division, U. S. A., Camp Upton, *New York.*

Lewis, Charles B., captain, Ordnance R. C., Camp Lewis, *American Lake, Wash.*

Lewis, Harry R., Jr., captain, Ordnance R. C., Springfield Armory, *Springfield, Mass.*

Libbey, E. B., captain, 102nd Ammunition Train, 27th Division, U. S. A., *Spartanburg, S. C.*

Lipsner, B. B., captain, Record Section, Aviation Section, Signal R. C., *Washington.*

McGill, Geo. E., Equipment Division, Aviation Section, Signal Corps, U. S. A., Packard Motor Car Co., *Detroit.*

McCormick, Bradley T., captain, Ordnance Department, U. S. A., *New York.*

McIntyre, H. C., captain, Ordnance R. C., *Washington.*

McMurtry, Alden L., captain, office of Surgeon General, Sanitary Corps, U. S. N. A., *Washington.*

Mackie, Mitchell, major, Quartermasters Corps, U. S. A., A. E. F., *France*, assigned to Motor Truck Transport Section.

MacCoull, Neil, Jr., U. S. N. R., *Washington.*

Marmon, Howard, major, Airplane Engineering Division, Signal R. C., McCook Field, *Dayton, Ohio.*

Marshall, W. C., captain, Ordnance R. C., *Washington.*

Martin, Kingsley G., captain, Quartermaster R. C., *Camp Dodge, Iowa.*

Mason, Geo. R., lieutenant, A. E. F., *France.*

Matthews, Meredith, sergeant of ordnance, 7th Mobile Ordnance Repair Shop, 7th Division, U. S. A., (mail) Camp McArthur, *Waco, Texas.*

May, Henry, Jr., first lieutenant, Quartermaster C., N. A., *Washington*, assigned as inspector of Type B engines.

May, O. J., captain, Aviation Section, Signal R. C., Camp Custer, *Battle Creek, Mich.*

Mergi, William, Co. B, First Battalion, 153d Depot Brigade, Camp Dix, *Wrightstown, N. J.*

Middleton, Ray T., first lieutenant, Air Service, A. E. F., *Paris, France.*

Miller, B. F., major, Quartermaster Corps, U. S. A., *Washington.*

Miller, C. A., first lieutenant, head checker, Quartermaster Corps, U. S. N. A., *Washington.*

Miller, Donald G., first lieutenant, Ordnance R. C., U. S. A., (mail) Nash Motors Co., *Kenosha, Wis.*

Mitchell, C. B., lieutenant, 4th Motor Mechanics' Regiment, *Camp Hancock, Ga.*

Moffat, Alex. W., ensign, commanding U. S. S. "Tamarack" (S. P. 561), Naval Defense Reserve, Postmaster, Foreign Station, *New York.*

MONCRIEFF, V. I., captain, Aviation Section, Signal R. C., *Washington.*

MORGAN, M. B., captain, Ordnance R. C., *Washington.*

MURPHY, JOSEPH G., Sanitary Corps, U. S. N. A., *Washington.*

MYERS, J. L., first lieutenant, Motor Equipment Section, Ordnance R. C., U. S. A., (mail) Allison Experimental Co., *Indianapolis.*

NAHIKIAN, S. M., lieutenant, Aviation School, Massachusetts Institute of Technology, *Cambridge, Mass.*

NORRIS, G. L., captain, Signal R. C., U. S. A., *Pittsburgh, Pa.*

OLDFIELD, LEE W., captain, Signal R. C., *Washington*, assigned as aeronautical engineer.

OLIPHANT, LAURENCE, ensign, U. S. N., *Washington.*

OMMUNDSON, H. P., Flying Corps, U. S. N., Aeronautic Station, *Pensacola, Fla.*

ORTON, EDWARD, JR., major, Quartermaster R. C., *Washington*, assigned to Motor Transport Branch, Engineering Section.

OTTO, HENRY S., lieutenant, Intelligence Section, A. E. F., *France.*

PAGE, VICTOR W., first lieutenant, Aviation Section, Signal R. C., *Mineola, N. Y.*

PAINE, C. L., captain, Ordnance R. C., U. S. A., Headquarters 7th Mobile Ordnance Repair Shop, Camp McArthur, *Waco, Texas.*

PARKER, RICHARD E., captain, Quartermaster R. C., *Washington*, assigned to Southern Department.

PEARMAIN, W. J., captain, Ordnance R. C., A. E. F., *France.*

PETERSON, F. SOMERS, ensign, Naval Air Station, *San Diego, Cal.*

PFEIFFER, BEN. S., first lieutenant, Ordnance R. C., Rock Island Arsenal, *Rock Island, Ill.*, assigned to Motor Section.

PIERCE, HUGH M., captain, Signal R. C., Call Field, *Wichita Falls, Texas*, assigned as engineer officer, Aviation Section.

POST, EDWIN M., JR., lieutenant, U. S. Air Service, A. E. F., *France.*

POTTER, AUSTIN E., lieutenant, U. S. N. R. F., U. S. Naval Aviation Forces, *France.*

POWELL, W. B., captain, assigned as officer in charge of mechanical transport, Imperial Ministry of Munitions, *Quebec, Can.*, (mail) P. O. Box 194.

PULLEN, DANIEL D., major, 7th Regiment, Engineer Corps, U. S. A., A. E. F., *France.*

PURCELL, BERNARD A., captain, Quartermaster R. C., 307th Supply Train, Camp Gordon, Ga., assigned as Commanding Officer.

RANNEY, A. ELLIOT, major, Air Division, Signal Corps, U. S. A., *Washington.*

RAWLEY, JOS., captain, Co. A, 310 Engineers, U. S. A., Camp Custer, *Battle Creek, Mich.*

RIDDLE, E. C., cadet, Aviation Section, Gerstner Field, *Lake Charles, La.*

RITTER, E. R., first lieutenant, Ordnance R. C., U. S. A., *Washington*, assigned to Production Division, Carriage Section.

ROBINSON, H. A., ensign, N. R., U. S. N., *Keyport, N. J.*

ROSE, CHARLES B., major, chief of planes and engine inspection, Inspection Department, Signal Corps, U. S. A., *Washington.*

ROSENTHAL, WM. C., sergeant, Engineer O. T. C., *Camp Lee, Va.*

ROUNDS, EDWARD W., U. S. N. R., U. S. Naval Aviation Detachment, *Cambridge, Mass.*

RUMNEY, MASON P., captain, Production Division, Ordnance R. C., *Washington.*

RUSSELL, EUGENE F., major, Ordnance Department, U. S. A., *Washington.*

SANDT, A. R., sergeant, Ordnance Department, U. S. A., *Washington*, assigned to Motor Equipment Section, Engineering Bureau.

SCHOENFUSS, F. H., captain, Gun Division, Production Section, Ordnance R. C., *Washington.*

SCHOEPF, T. N., captain, Engineer R. C., *Washington.*

SCOTT, ALLISON F. H., captain, Signal Corps, U. S. A., Langley Field, *Hampton, Va.*, assigned to Aviation Section.

SELFRIDGE, S. W., first lieutenant, Ordnance R. C., *Washington.*

SHAFER, M. S., second lieutenant, Signal R. C., McCook Field, *Dayton, Ohio*, assigned to Airplane Eng. Div.

SLADE, ARTHUR J., captain, Aviation Section, Signal R. C., *Washington.*

SMITH, EDSON H., ensign, U. S. N. R., (mail) American & British Mfg. Co., *Bridgeport, Conn.*, assigned as assistant naval inspector of Ordnance.

SMITH, FRANK E., major, Signal Corps, U. S. A., *Washington.*

SMITH, G. W., JR., lieutenant, U. S. N. R., Naval Aircraft Factory, U. S. Navy Yard, *Philadelphia.*

SMITH, MARK A., first lieutenant, Marine Corps, U. S. N., *Washington.*

SPRAGUE, G. A., Co. D, 310th Engineers, Camp Custer, *Battle Creek, Mich.*

STAHL, R., lieutenant, U. S. Navy Seaplane Division, U. S. N. R., *Washington.*

STEINAU, J. M., sergeant, sanitary Corps, U. S. N. A., *Washington.*

STEVENS, C. C., Motor Equipment Section, Ordnance Department, U. S. A., *Washington*, assigned as draftsman.

STRAHLMAN, OTTO E., first lieutenant, Aviation Section, Signal R. C., (mail) Mechanics Training School, Overland Bldg., *St. Paul, Minn.*

STREETER, ROBT. L., major, Ordnance Department, U. S. A., *Rock Island Arsenal, Ill.*, in charge of truck and tractor experimental work.

SWEET, GEO. P., first lieutenant, Signal Corps, U. S. A., *Washington*, assigned to Aviation Section.

SWEET, GEO. W., captain, Ordnance Department, U. S. A., *Washington*, assigned as inspector of ordnance, Studebaker Corp., *South Bend, Ind.*

SWINTON, D. R., first lieutenant, Quartermaster Corps, U. S. N. A., Mobile Repair Shop 302, A. P. O. 708, A. E. F., via New York.

TAYLOR, PAUL B., sergeant, Medical Corps, U. S. A., *Pontiac, Mich.*

TAYLOR, S. G., JR., first lieutenant, Ordnance R. C., *Washington*, assigned to Ordnance Department.

TEETOR, D. C., captain, Ordnance R. C., *Kenosha, Wis.*, assigned to Motor Section.

THOMPSON, H. E., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance R. C., *Washington.*

THOMPSON, JOHN A., Ordnance Department, U. S. A., assigned to Engineering Bureau, Motor Equipment Section, Ford Bldg., *Washington.*

THOMSON, CLARKE, lieutenant, Signal R. C., *Washington.*

TITSCH, WALTER H., captain, Quartermaster Corps, U. S. N. A., A. E. F., *France.*

TOLMAN, EDGAR BRONSON, JR., first lieutenant, 311th Engineers, U. S. A., Camp Grant, *Rockford, Ill.*

TURNER, HARRY C., captain, Engineer R. C., A. E. F., *France.*

TWACHTMAN, QUENTIN, first lieutenant, Engine Design Section, Signal R. C., *Washington.*

UNDERHILL, C. R., captain, Radio Section, Signal R. C., *Washington.*

VAIL, E. L., lieutenant, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned as officer in charge of instruments and accessories.

VERITY, CALVIN W., captain, superintendent of forge shop, Ordnance R. C., Frankfort Arsenal, *Philadelphia.*

VINCENT, JESSE G., lieutenant colonel, Aviation Section, Signal Corps, U. S. A., Miami Hotel, *Dayton, Ohio.*

VONACHEN, F. J., lieutenant, Ordnance Department, U. S. N. A., Rock Island Arsenal, *Rock Island, Ill.*

WALDON, SIDNEY D., colonel, Equipment Division, Signal Corps, U. S. A., *Washington.*

WALL, WILLIAM GUY, major, Ordnance Department, U. S. A., A. E. F., *France.*

WALTER, MAURICE, first lieutenant, Ordnance R. C., *Washington.*

WALTON, FRANK, acting sergeant, Quartermaster Corps, U. S. A., Quartermaster Repair Unit, (mail) *Washington, D. C.*

WALTON, HAROLD E., 84th Aero Squadron, Signal Corps., U. S. A., Kelly Field, *San Antonio, Texas.*

WEAVER, E. W., aeronautical engineer, Engineering Department, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

WEISS, ERWIN A., sergeant, Ordnance Department, U. S. A., *Washington*, assigned to Engineering Bureau, Motor Section.

WELSH, W. E., Signal Corps, Aviation Section, U. S. A., *Washington.*

WETHERELL, S. P. JR., major, Quartermaster R. C., Motor Transport Service, A. E. F., *France.*

WHITTENBERGER, OWEN M., first lieutenant, Ordnance R. C., *Washington*, assigned to Office of Chief of Ordnance.

WILSON, T. S., lieutenant colonel, Field Artillery, *Santa Fe, N. M.*

WODEHOUSE, B. A., sergeant, Co. A, 339th Infantry, *Camp Custer, Mich.*

WOLFF, RUDOLPH D., U. S. N. R. F. No. 5, Great Lakes, U. S. A., assigned as chief petty officer.

WOOD, C. G., first lieutenant, Quartermaster Corps, U. S. A., *Washington*, assigned to Motor Transport Section, Office of Quartermaster general.

WOOD, HAROLD F., lieutenant, Specification Section, Equipment Division, Signal R. C., *Washington.*

WOODS, S. H., captain, Military Truck Production Section, Office of Quartermaster General, *Washington.*

WORKMAN, LEE W., 670th Aero Squadron, Aviation Branch, *Morrison, Va.*

YONKIN, HARRY F., first lieutenant, Ordnance R. C., A. E. F., *France.*

CIVILIAN HONOR ROLL

ADAMS, PORTER H., Office of the Section Commander, First Naval District, *Rockford, Me.*

ADAMS, H. J., War Industries Board, *Washington.*

AGINS, HERMAN J., draftsman, Quartermaster Corps, U. S. A., *Washington*, assigned to Motor Transport Division.

ANDERSON, E. S., mechanical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, N. Island, *San Diego, Cal.*

ANDERSON, H. C., aeronautical mechanical engineer, Production Engineering Department, Equipment Division, Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio.*

BARE, ERWIN L., automobile body designer, Office of Quartermaster General, *Washington.*

BARNABY, RALPH S., airplane inspector, Naval Reserve Flying Corps, *Buffalo, N. Y.*

BARNHARDT, GEO. E., aeronautical mechanical engineer, Signal Corps., U. S. A., Wilbur Wright Field, *Dayton, Ohio*, (mail) Cottage B6, Unit No. 1, Signal Corps, Aviation School, *Fairfield, Ohio.*

BARTON, CHAS. E., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, assigned to Airplane Eng. Department.

BELLING, G. C. C., assistant inspector of engineering material, U. S. NAVY, *Buffalo, N. Y.*, (mail) Curtiss Aeroplane & Motor Corp.

BOOTH, FRED C., draftsman, Motor Transport Division, Quartermaster Department, U. S. A., *Washington*, (mail) Room 205, Union Station.

BOURQUIN, J. F., supervisor of chassis assembly, Military Truck Production Section, Office of Quartermaster General, *Washington.*

BRADFIELD, E. S., Engineering Department, Naval Factory, *Philadelphia.*

BURTON, W. DEAN, aeronautical mechanical engineer, Signal Corps, U. S. A., *Fort Omaha, Neb.*

CALDWELL, FRANK W., aeronautical engineer, Aviation Section, Signal Corps, U. S. A., (mail) McCook Field, *Dayton, Ohio.*

CHAPMAN, ROBERT H., U. S. N., Spartanburg, S. C., assigned to Aeronautical Division.

CHAUVEAU, ROGER, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*

CHERRY, RALPH E., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to Airplane Engineering Department.

CLARK, ELMER J., Signal Corps, U. S. A., *Portland, Ore.,* assigned as district manager of inspection.

CLARKE, THOMAS A., Signal Corps, U. S. A., *Washington,* assigned to Aviation Section as production expert.

CLEAVER, B. J., Medical Corps, U. S. A., General Motors Truck Plant, *Pontiac, Mich.*

COFFIN, HOWARD E., chairman, Aircraft Board, *Washington.*

COSTELLO, JOHN V., aeronautical engineer, airplane engineering division, Signal Corps, *Dayton, Ohio.*

CROW, HAROLD I., School of Military Aeronautics, University of California, *Berkeley, Cal.,* assigned as instructor in aeronautic engines.

DEKLYN, JOHN H., technical assistant, National Advisory Committee on Aeronautics, *Washington.*

DICK, ROBERT I., motor truck expert, Ordnance Department, *Camp Dodge, Iowa.*

DIFFIN, F. G., chairman, International Aircraft Standards Board, *Washington.*

DUVAL, EUGENE C., Signal Corps, U. S. A., assigned to Airplane Engineering Department, Mutual Home Bldg., *Dayton, Ohio.*

EDGERTON, A. H., Signal Corps, U. S. A., 870 Woodward Ave., *Detroit,* assigned to Equipment Division as gage supervisor.

EDMONDSON, D. E., U. S. Signal Service at Large, *Washington,* assigned as inspector of airplanes and airplane engines, Ericsson Mfg. Co., *Buffalo.*

EISELE, WILLIAM S., draftsman, Aviation Section, Signal Corps, U. S. A., *Washington.*

ELLIOTT, E. M., chief dispatcher, Emergency Fleet Corp., *Washington.*

ERICSON, FRIEHOF G., representative of Canada, International Aircraft Standards Board, *Washington.*

FERRY, PHILLIPS B., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

FOWLER, HARLAN D., aeronautical engineer, Production Engineering Division, Aviation Section, Signal Corps, *Washington.*

FROESCH, CHARLES, aeronautical mechanical engineer, Engineering Department, New York Equipment District, Aviation Section, Signal Corps, (mail) Aeronautical Engines Corps, *Long Island City, N. Y.*

GIRL, CHRISTIAN, director, Military Truck Production Section, Office of Quartermaster General, *Washington.*

GRIMES, C. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to airplane engineering department.

GORMAN, E. J. B., U. S. Flying Corps, N. R., U. S. N., *Dayton, Ohio,* assigned to inspection of airplane engines, Dayton-Wright Aeroplane Co.

GRIFFITH, LEIGH M., technical expert, National Advisory Committee for Aeronautics, 518 Munsey Bldg., *Washington.*

GUERNSEY, CHAS., chief draftsman, Quartermaster Corps, U. S. A., *Washington,* assigned to Engineering Section, Motors Division.

HALE, W. A., aeronautical mechanical engineer, Signal Corps, U. S. A., *Dayton, Ohio.*

HALLETT, GEO. E. A., aeronautical mechanical engineer, Aviation Section, Signal Corps, Arcade Bldg., *Washington.*

HARRIGAN, F. P., Signal Corps, U. S. A., McCook Field, *Dayton, Ohio,* assigned to Plane Design Section.

HECKEL, C. E., truck designer, Transport Division, Quartermaster Corps, U. S. A., *Washington.*

HICKS, HARLIE H., airplane engineering division, Signal Corps, U. S. A., *Dayton, Ohio.*

HOBBS, J. W., automobile expert, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*

HOLDEN, F. M., airplane engineering division, Signal Corps, U. S. A., *Washington.*

HONIGMAN, JOS. K., instructor, U. S. School of Military Aeronautics, Princeton University, *Princeton, N. J.*

HORNING, H. L., chief, Automotive Products Section, War Industries Board, *Washington.*

KING, CHARLES B., aeronautical engineer, Aviation Section, Signal Corps, *Washington.*

KISHLINE, FLOYD F., laboratory assistant, Quartermaster Corps, *Washington.*

KROEGER, F. C., Quartermaster Corps, U. S. A., *Washington,* assigned as engineer on electrical equipment.

KUEMPEL, REUBEN, U. S. N., Naval Air Station, *Pensacola, Fla.,* assigned to Bureau of Steam Engineering.

LADDON, I. M., aeronautical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

LANE, ABBOTT A., inspector, Aviation Section, Signal Corps, (mail) Room 52, 870 Woodward Avenue, *Detroit.*

LEOPOLD, JOS., Engineers' School, U. S. School of Military Aeronautics, Ohio State University, *Columbus, Ohio.*

LINCOLN, C. W., aeronautical engineer, airplane engine department, Equipment Division, Signal Corps, U. S. A., *Washington.*

LONGLETZ, WESLEY, Signal Corps, U. S. A., assigned as inspector on airplane engines at The Nordyke & Marmon Co., *Indianapolis.*

MCCAIN, GEO. L., Signal Corps, U. S. A., *Dayton, Ohio,* assigned to airplane engineering department, Engine Design Section.

MCMASTER, MARCENUS D., aeronautical engineer, Motor Transportation Department, Signal Corps, *Washington.*

MENNEN, F. E., Quartermaster Corps, U. S. A., *Washington,* assigned to Transportation Division.

MILLAR, THOMAS H., JR., Engineering Section, Motors Division, Quartermaster Corps, *Washington,* (mail) Office of Quartermaster General.

MOORHOUSE, A., Signal Corps, U. S. A., Lindsey Bldg., *Dayton, Ohio,* assigned as engineer in Airplane Eng. Dept.

MORGAN, G. W., supervisor of plant survey, Military Truck Production Section, Office of Quartermaster General, *Washington.*

NELSON, A. L., aeronautical engineer, Aeroplane Engineering Department, Aviation Section, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

NEUMANN, JOHN W., Planning Section, Machine Division, U. S. Navy Yard, *Philadelphia.*

O'MALLEY, JOHN M., aeronautical engineer, Aviation Section, Signal Corps, U. S. A., Rockwell Field, *San Diego, Cal.*

OTIS, J. HAWLEY, Ordnance Department, U. S. A., Camp Dodge, *Des Moines, Iowa.*

PARISH, W. F., Signal Corps, U. S. A., *Washington,* assigned to Specification Section, Equipment Division.

PARKER, VICTOR C., Signal Corps, U. S. A., *Washington,* assigned to Equipment Division.

PARRIS, JR., EDWARD L., senior inspector, Aviation Section, Signal Corps, (mail) Ericsson Mfg. Co., *Buffalo.*

PERRIN, J. G., aeronautical engineer, Production Engineering Department, Aviation Section, Signal Corps, U. S. A., *Buffalo, N. Y.*

POLLOCK, RAY C., Signal Corps, U. S. A., *Buffalo,* assigned as airplane engine inspector.

PROCTOR, C. D., Ordnance Department, U. S. A., Rock Island Arsenal, *Rock Island, Ill.,* assigned to Motor Section, Carriage Division.

RICE, HARVEY M., inspector, Signal Service at Large, Signal Corps, (mail) Willys-Overland Co., *Toledo, Ohio.*

RIPPINGILLE, E. V., Aviation Section, Signal Corps, *Washington.*

ROGERS, JOHN M., aeronautical engineer, Bureau of Construction & Repair, Navy Department, *Washington.*

RUCKSTELL, G. E., Signal Corps, U. S. A., assigned as aeronautical mechanical engineer, *Detroit.*

RYMARCZICK, GUSTAV M., Signal Corps, U. S. A., (mail) Splitdorf Electrical Co., *Newark, N. J.,* assigned to Aviation Sect., as senior inspector, Signal Service at Large.

SALISBURY, EDWARD V., chief of motor transportation, American International Corp., Government Shipbuilding Yard, Hog Island, *Philadelphia.*

SCHAUM, OTTO W., Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio,* assigned as aeronautical mechanical engineer, Production Engineering Department.

SCHELL, JOHN A., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

SEABURY, W. M., Field Hospital, No. 337, Camp Custer, *Battle Creek, Mich.*

SEABURY, W. WARNER, Signal Corps, U. S. A., Bureau of Standards, *Washington,* assigned to testing of aviation instruments.

SEARLE, C. A., auto-parts inspector, U. S. A., *Washington.*

SELLERS, MATTHEW B., Naval Consulting Board, *New York.*

SERRELL, ERNEST, aeronautical mechanical engineer, Aviation Section, Signal Corps, *Washington.*

SHILLINGER, G. P., Ground Officers' Engineering School, Kelly Field No. 1, *San Antonio, Tex.,* assigned as instructor in ignition, starting and lighting.

SIMPSON, HOWARD W., Signal Corps, U. S. A., *Detroit,* assigned as inspector of aircraft engines, Inspection Section, *Equipment Division,* (mail) 870 Woodward Ave.

STANTON, D. T., military instructor, U. S. Army School of Military Aeronautics, Cornell University, *Ithaca, N. Y.*

STOUT, WILLIAM B., technical adviser, International Aircraft Standards Board, *Washington.*

STUART, H. R., Signal Corps, U. S. A., Lindsey Building, *Dayton, Ohio,* assigned as aeronautical mechanical engineer, Production Engineering Department.

THIBAULT, F. J., aeronautical mechanical engineer, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio.*

TONE, FRED I., inspector, Aviation Section, Signal Corps, *Washington.*

TRACY, PERCY WHEELER, supervisor of parts plants, Military Truck Production Section, Office of Quartermaster General, *Washington.*

UTZ, JOHN G., supervisor of inspection, Office of Military Truck Production Section, Office of Quartermaster General, *Washington.*

VAN LOON, HENRY M., 310th Engineers, Camp Custer, *Battle Creek, Mich.*

VOHRER, W. R., draftsman, Engineering Section, Motor Division, Quartermaster Corps, U. S. A., *Washington.*

WADE, GUSTAV, inspector, Aviation Section, Signal Corps, *Dayton, Ohio.*

WALDON, C. O., National Bureau of Standards, *Washington,* assigned as laboratory assistant, Military Research Gas Engines.

WALDRON, RUSSELL E., Signal Corps, U. S. A., Detroit, assigned to Equipment Division.

WALKER, KARL F., automotive engineer, Quartermaster Corps, U. S. A., *Washington,* assigned to Engineering Laboratory.

WALTER, JOHN M., mechanical draftsman, Bureau of Ordnance, Navy Department, *Washington.*

WARNER, EDWARD P., aeronautical engineer, Signal Service at Large, U. S. A., Mass. Institute of Technology, *Cambridge, Mass.*

WATERHOUSE, W. J., aeronautical engineer, Aviation Section, Signal Corps, (mail) Dayton-Wright Airplane Co., *Dayton, Ohio.*

WHINNE, WILBUR H., inspector, Quartermaster Corps, U. S. A., *Detroit.*

WILLIAMS, S. T., Naval Aircraft Factory, Navy Yard, *Philadelphia, Pa.*, assigned as aeronautical mechanical engineer in Engineering Department.

WINTER, E. A., War Department, Rock Island Arsenal, *Rock Island, Ill.*

WORTHEN, C. B., inspector, Aviation Section, Signal Corps, U. S. A., *Washington.*

YOUNGER, JOHN, Quartermaster Corps, U. S. A., *Washington*, assigned to Motor Transportation Engineering Office, as supervisor of engineering.

Applications *for* Membership

The applications for membership received between April 10 and May 22, 1918, are given below. The members of the Society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ANDERSON, CARL LUDWIG, superintendent, Mechanics Machine Co., *Rockford, Ill.*

BARKER, GEORGE E., auditor, Perfex Radiator Co., *Racine, Wis.*

BLOMGREN, OSCAR, draftsman, International Motor Co., *New York.*

BOYER, WALLACE E., assistant foreman, T. E. Adams, Inc., *New York.*

BOEHME, PAUL L., production clerk, Ord. R. C., U. S. A., *Peoria, Ill.*

BRADLEY, ROBERT G., western representative, Spring Division, Standard Parts Co., *Cleveland.*

BRANDIMORE, J. C., special factory representative, Mitchell Motors Co., Inc., *Racine, Wis.*

BRANNAN, L. M., chief engineer, Teetor-Hartley Motor Corp., *Hagerstown, Ind.*

BROWN, J. CLIFTON, proprietor, Willard Battery Service Station, *Sumter, S. C.*

BURNETT, ROBERT S., Standards Department, Society of Automotive Engineers, *New York.*

CARR, BYRON, superintendent, Overland Pacific Co., *Seattle, Wash.*

CARTER, EDGAR ROBERT, JR., mechanical engineer, The Fafnir Bearing Co., *New Britain, Conn.*

CHAMBERLAIN, WILLIAM A., aeronautical engineer, Production Engineering Dept., Signal Corps, U. S. Army, *Washington.*

CRAWFORD, DAVID FERGUSON, designing engineer, Lyons Atlas Co., *Indianapolis.*

DAUM, GEORGE W., general superintendent, Pennsylvania Rubber Co., *Jeannette, Pa.*

DAVIS, RALPH W., chief engineer, Mitchell Motors Co., *Racine, Wis.*

ECHLIN, E. S., assistant research engineer, J. I. Case Threshing Machine Co., *Racine, Wis.*

EISENBERG, SAMUEL B., draftsman, Chevrolet Motor Co., *New York.*

ELLIS, RUSSELL S., vice-president, general manager, Motor Efficiency Corp., *Philadelphia.*

EWALD, HENRY T., president, Campbell-Ewald Co., *W. Detroit.*

GEILKER, WALTER L., designing engineer, Lyons Atlas Co., *Indianapolis.*

HALSEY, W. D., mechanical engineer, National Advisory Committee for Aeronautics, *Washington.*

HESS, SAMUEL P., assistant manager, spring department, Detroit Steel Products Co., *Detroit.*

HINDS, WILLIAM RAYMOND, Co. B, 310 F. S. Bureau, *Camp Custer, Mich.*

HIRTZEL, MAJOR CLEMENT HENRY A., (Section Director), Royal Air Force and Aircraft Production, Air Board, London.

HOUSE, HARRY A., JR., chief engineer, Wire Wheel Corp. of America, *Buffalo, N. Y.*

HUDSON, W. R., associate manager, Troy Wagon Works, *Troy, Ohio.*

HURD, ROLLIN V., sales manager, Victory Screw Works, *Detroit.*

JACOBSSON, BIRGER, manager, Scandinavian Department, J. B. Crockett Co., Inc., *New York.*

KAMPS, G. B., chief engineer, The Four Drive Tractor Co., *Big Rapids, Mich.*

KAUFFMAN, S., president, engineer, Kauffman Engineering Co., *St. Louis.*

KIMBALL, H. G., patent lawyer, Wetmore & Jenner, *New York.*

KARLL, W. R., chief engineer, Perfex Radiator Co., *Racine, Wis.*

KATELEY, FRANK A., chief engineer, Hebb Motors Co., *Detroit.*

KEELOR, E. R., automotive engineer, Motors Division, Quartermaster Corps, *Washington.*

KLINGER, P. W., chief engineer, Dayton Steel Foundry Co., *Dayton, Ohio.*

LANG, GUSTAVE J., chief engineer, Bosch Magneto Co., *New York.*

LANDAUER, ARTHUR, engine tester, Joseph Tracy Laboratory, *New York.*

LATTNER, PAUL M., proprietor, Electric Service Station, *Cedar Rapids, Iowa.*

LORENZ, HAROLD V., draftsman, Twin City Four Wheel Drive Co., *St. Paul, Minn.*

LOVE, JOHN E., sales agent, 1156 Penobscot Bldg., *Detroit.*

LOWE, FRANK JOHN, superintendent, Bronx County Auto Co., *Bronx.*

MACKLE, JOSEPH A., director, general manager, Willys-Overland Ltd., 151-153 Great Portland St., *London, W. I., Eng.*

MARCUS, CHARLES, vice-president, Auto Electric & Service Corp., *Detroit.*

MARTINDALE, THOMAS B., automobile agent, 3437 N. Broad St., *Philadelphia.*

MCDOWELL, C. W., general factory superintendent, Mitchell Motors Co., *Racine, Wis.*

MILLER, LESTERE, metal purchasing agent, Standard Aircraft Corp., *Elizabeth, N. J.*

NELSON, JOHN H., research engineer, Wyman & Gordon Co., *Worcester, Mass.*

NILSON, CARL, metallurgical inspection, Quartermaster Corps, U. S. A., *Detroit.*

OPITZ, F. M., president, factory manager, Perfex Radiator Co., *Racine, Wis.*

ORROK, GEO. A., consulting engineer, 17 Battery Place, *New York.*

PARKER, CHARLES LESLIE, partner, Parker Motor Car Co., *Seattle, Wash.*

PARSONS, HARRY N., chief draftsman, U. S. Ball Bearing Mfg. Co., *Chicago.*

PETERSON, JOHN W., factory manager, King Motor Car Co., *Detroit.*

POLLOCK, ROBERT T., president, treasurer, Robert T. Pollock Co., *Boston.*

POMEROY, GLENDON MILLER, aeronautical engineer, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

RABEZZANA, HECTOR, experimental engineer, Champion Ignition Co., *Flint, Mich.*

RADACK, HARRY E., automotive engineer, Motor Transport Division, Quartermaster Corps, *Washington.*

RIEMAN, CHARLES S., president and general manager, Elgin Motor Car Corp., *Argo, Ill.*

ROBERTSON, WALTER E., president, The Robertson Cradlelock Wheel Co., *Chicago.*

SCHMIDT, FREDERICK J., draftsman, International Motor Co., *New York.*

SHARP, H. OAKLEY, chief engineer, West Side Foundry Co., *Troy, N. Y.*

SKIMP, HAYES G., assistant manager, Bearings Co. of America, *Lancaster, Pa.*

SMITH, DONALD BAKER, designing engineer, Lyons Atlas Co., *Indianapolis.*

SMITH, HAROLD C., president, general manager, Illinois Tool Works, *Chicago.*

SPAULDING, ALBERT B., inventor, 227 W. Cedar St., *Springfield, Ill.*

STEPHENSON, GEO. F., manager, Earl P. Cooper Co.; western representative, engineer, Wisconsin Motor Mfg. Co., *Los Angeles, Cal.*

STORER, FRANK A., general manager, Wire Wheel Corp. of America, *Buffalo, N. Y.*

STONE, E. WADSWORTH, assistant production manager, Whitehouse Le Compte Mfg. Co., *Newark, N. J.*

TAINSH, JOHN, sales manager, Mitchell Motors Co., *Racine, Wis.*

THREADER, WILFRED G., 1st Lieut., Aviation Section, Signal Reserve Corps, U. S. A., Langley Field, *Hampton, Va.*

TILLSON, BENJAMIN FRANKLIN, engineer, head of mining department, New Jersey Zinc Co., *Franklin, N. J.*

TILT, CAPTAIN ALBERT, charge of development and purchase of fabrics, dopes and other materials for aviation work, Equipment Division, Signal Corps, *Washington.*

TRASK, CLYDE W., draftsman, engineer, Dort Motor Car Co., *Flint, Mich.*

TREFZER, JACQUES A., draftsman, Cadillac Motor Car Co., *Detroit.*

TURNBULL, WILLIAM, chief engineer, The Holt Mfg. Co., *Peoria, Ill.*

VAN DER LINDE, VICTOR G., development manager, The B. F. Goodrich Co., *Akron, Ohio.*

VREELAND, EDWARD E., president, Abbot & Downing Co., *Concord, N. H.*

WELKE, ALBERT E., superintendent, Northwest Motor Co., *Seattle, Wash.*

WELLS, GEORGE B., sergeant, first class, tire construction engineer, Engineering Branch, Q. M. C., Motor Transport Service, *Washington.*

WHITE, GUY A., charge of production and heat treatment, Curtiss Aeroplane & Motor Co., *Hammondsport, N. Y.*

WOLF, E. P., vice-president, treasurer, Perfex Radiator Co., *Racine, Wis.*

ZEITLER, RAYMOND S., president, chief engineer, Zeitler Gas Car & Locomotive Co., *Chicago.*

ZWALLEY, E. L., road engineer, Mitchell Motors Co., *Racine, Wis.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between April 10 and May 14, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ADAMS, EDWARD T. (Aff. Rep.) chief engineer, Stumpf Una-Flow Engine Co., Inc., 401 S. A. & K. Bldg., *Syracuse, N. Y.*

BAIER, R. E. (A) purchasing agent, Sandow Motor Truck Co., *Chicago.* (mail) 6516 Greenwood Ave.

BALDRY, HERBERT C. (A) vice-president, The Flour City Ornamental Iron Co., *Minneapolis, Minn.*

BARBAROU, MARIUS (M) general manager, Societe Lorraine des Anciens Etablissements de Dietrich & Cie, Route de Bezons, *Argenteuil, France.*

BENJAMIN, DAVIS (A) purchasing agent, assistant to office and factory manager, Gabriel Mfg. Co., 1407 E. 40th st., *Cleveland.*

BENNETT, E. O. (J) mechanical engineer, National Advisory Committee for Aeronautics, 518 Munsey Bldg., *Washington.*

BERGENHOLTZ, N. G. (M) designer, The Militor Corp., Bergen & Kearney Aves., Jersey City, N. J. (mail) 490 Hawthorne Ave., *Newark, N. J.*

BEST, C. L. (Aff. Rep.) vice-president, C. L. Best Gas Traction Co., *San Leandro, Cal.*

BEST GAS TRACTION CO., C. L. (Aff. Mem.) *San Leandro, Cal.* Representatives; C. A. Hawkins, president; C. L. Best, vice-president.

BLAKE, H. C. (M) secretary, The Foos Gas Engine Co., *Springfield, Ohio.*

BUBNA, RICHARD C. (J) designer, Engineering Office, Transport Div., Quartermaster Corps, U. S. A., Room 305 Union Station, Washington, (mail) 31 Kalorama Apts., 1816 Kalorama Road, *Washington.*

BREEZE, GEORGE ALMOND, (M) assistant engineer, Holley Carburetor Co., 145-147 Willis Ave. E., *Detroit.* (mail) 1451 Seminole Ave.

BROADWELL, E. H., (A) vice-president, The Fisk Rubber Co., *Chicopee Falls, Mass.*

BROWN, WILLIAM CLINTON (Aff. Rep.) general manager, Stumpf-Una-Flow Engine Co., Inc., 401 S. A. & K. Bldg., *Syracuse, N. Y.*

BRUNNER, GEO. L. (M) treasurer, general manager, Brunner Mfg. Co., *Utica, N. Y.*

BULL, EZRA C. (M) president, advisory engineer, Super-Lighting Co., Inc., Rooms 241-242, 1834 Broadway, *New York.*

BULLOCK, WILLIAM E. (A) assistant secretary, American Society of Mechanical Engineers, 29 W. 39th St., *New York.* (mail) 26 Maxweber Ave., *Jamaica, N. Y.*

BUSHNELL, PHILIP S. (M) assistant engineer, The Standard Parts Co., Hickox Bldg., *Cleveland.*

BUZARD, JAMES A. (S. E.) student, University of Washington, Seattle, Wash. (mail) Hunts Point, Madison Park, *Seattle, Wash.*

CARTER, T. ARMSTRONG (M) service manager, Maxwell Motor Co., Ltd., 212 Great Portland St., *London W. 1, Eng.*

CARPENTER, FOREST L. (J) layout draftsman, Chevrolet Motor Co., 619 W. 56th St., *New York.*

CASTLE, S. M. (M) engineer, General Electric Co., 120 Broadway, *New York.*

CLEMENTS, FRANK O. (M) director of research work, The Dayton Metal Products Co., Research Division, 127 N. Ludlow St., *Dayton, Ohio.*

COMSTOCK, HERBERT F., cadet, (A) Aviation Section, Signal Corps, U. S. A., American Expeditionary Forces, 16th Foreign Detachment, A. P. O., 725, via New York. (mail) care H. D. Comstock, *Mitchell, Nebr.*

COOK, M. H. (J) draftsman, Motor Transport Section, Quartermaster Corps, U. S. A., Room 205, Union Station, *Washington.*

CRAVENS, GEO. W. (M) general manager, American Motors Corp., *Plainfield, N. J.,* (mail) *Westfield, N. J.*

CUTLER, WAYNE H. (A) purchasing agent, Knox Motors Co., 53 Wilbraham Road, *Springfield, Mass.*

DENKINGER, GEORGE MARSHALL (M) instructor in aero engineering, Massachusetts Institute of Technology, *Cambridge, Mass.;* aeronautical engineer, Aviation Section, Signal Corps, U. S. A., *Washington,* (mail) 46 St. John St., *Jamaica Plain, Mass.*

DICKSON, J. B. (A) service manager, secretary, Automobile Sales Corp., 142 N. Broad St., *Philadelphia,* (mail) 246 S. 51st St.

DOUGLAS, HARRY A. (M) president, general manager, Douglas & Rudd Mfg. Co., *Bronson, Mich.*

DRESSER, L. W. (J) mechanical engineer, draftsman, Engineering Section, Motor Transport Div., Quartermaster Corps, U. S. A., Room 306, Union Station, *Washington.*

DURHAN, EDWARD, JR. (S. E.) student, Armour Institute of Technology, *Chicago,* (mail) 1949 S. Sawyer Ave.

EDWARDS, HENRY H. (M) vice-president, The Bantam Ball Bearing Co., *Bantam, Conn.*

FLOGAUS, H. A. (J) designer, checker, Motor Transport Engineering Division, U. S. A., Office of Quartermaster General, 205 Union Station, *Washington,* (mail) 1746 Columbia Road.

GAMMETER, JOHN R. (M) mechanical engineer, The B. F. Goodrich Co., *Akron, Ohio.*

GORDON, H. C. (A) foreman, motor assembly department, Waterloo Gasoline Engine Co., *Waterloo, Iowa,* (mail) 206 Lane St.

GRAVEL, JOSEPH L. (J) designing engineer, Willys-Overland Co., *Toledo, Ohio,* (mail) Navarre Hotel.

GREEN, L. P. (A) production manager, Cleveland Knife & Forge Co., *Cleveland,* (mail) 1960 W. 114th St.

GREEN, WILLARD C. (M) director of research, Super-Lighting Co., Inc., 1834 Broadway,*New York,* (mail) Engineering Service Laboratories, *E. Orange, N. J.*

HAHL, GEO. E. (A) sales engineer, Doehler Die-Casting Co., Court and Ninth Sts., *Brooklyn, N. Y.,* (mail) 182 Central Ave., *E. Orange, N. J.*

HARKNESS, E. L. (M) engineering assistant, Aeronautical Engine Corp., *Long Island City, N. Y.*

HARRIS, FREDERICK E. (A) salesman, Hoyt Metal Co., *St. Louis,* (mail) 308 Moffat Bldg., *Detroit.*

HAWKINS, C. A. (Aff. Rep.) president, C. L. Best Gas Traction Co., *San Leandro, Cal.*

HERRINGTON, ARTHUR W. S. (M) first lieutenant, Engineering Section, Motors Division, Quartermaster Corps, U. S. A., *Washington,* (mail) Engineering Section, Motors Division, Office of Quartermaster General, Room 203, Union Station, *Washington.*

HEUTTICH, R. C. (M) superintendent, Brierley Machine Co., *Cleveland,* (mail) 7708 Hough Ave.

HEYWOOD, CHARLES E. (J) publication department, Society of Automotive Engineers, 29 W. 39th St., *New York,* (mail) 415 Fort Washington Ave.

HIGGINS, GEORGE H. (M) factory manager, Burd High Compression Ring Co., 23d Ave. and 10th St., *Rockford, Ill.*

HINZ, JULIUS C. (A) president, general manager, Bellevue Industrial Furnace Co., 703 Bellevue Ave., *Detroit.*

HODGKINS, MERTON O. (J) designing draftsman, checker, Curtiss Engineering Corp., *Garden City, N. Y.,* (mail) 156 Atlantic Ave., *Hempstead, N. Y.*

HOLLERITH, CHARLES (J) chief engine test inspector, Nordyke & Marmon Co., *Indianapolis,* (mail) 6 W. Michigan St.

HOLLERITH, HERMAN, JR. (J) engineer, Naval Aircraft Factory, U. S. Navy Yard, *Philadelphia,* (mail) Lenox Apartments, 13th and Spruce Sts., *Philadelphia.*

IKERT, B. M. (A) technical editor, Class Journal Co. (Motor Age), 5 S. Wabash Ave., *Chicago,* (mail) 493 North St., *Elgin, Ill.*

JANDUS, HERBERT S. (M) assistant engineer, axle department, The Standard Parts Co., Hickox Bldg., *Cleveland.*

JONES, EDWARD L. (A) salesman, The Standard Parts Co., *Cleveland.*

KENT, B. M. (M) patent counsel, The Standard Parts Co., *Cleveland.*

KLOER, CHARLES H. (M) designer, Duesenberg Motors Corp., *Elizabeth, N. J.,* (mail) 612 Bramha Ave., *Jersey City, N. J.*

KNOBLOCH, W. H. (M) factory manager, Weidely Motors Co., *Indianapolis;* Cleveland Tractor Co., *Cleveland;* (mail) 3355 College Ave., *Indianapolis.*

KUHSICK, ALBERT J. H. (A) superintendent, Edward V. Hartford, Inc., 143 Morgan St., *Jersey City, N. J.* (mail) Lefferts and Hillside Aves., *Richmond Hill, L. I., N. Y.*

LEE, H. F. (M) superintendent, chief engineer, Ditwiler Mfg. Co., *Galion, Ohio.*

LINDBERG, ERNEST O. (J) designer, The Militor Corp., Bergen and Kearney Aves., *Jersey City, N. J.,* (mail) 932 Hudson St., *Hoboken, N. J.*

LOESER, WILLIAM G. (A) assistant sales manager, The Moto-Meter Co., Inc., 15 Wilbur Ave., Long Island City, N. Y., (mail) 120 Lewis Ave., *Elmhurst, N. Y.*

LONGWELL, JAMES R. (M) district representative, Curtiss Aeroplane & Motor Corp., Hammondsport, N. Y., (mail) Box 444, *Pottstown, Pa.*

LONN, JULIUS M. (J) first lieutenant, inspection officer, Ordnance Reserve Corps, U. S. A., Frankford Arsenal, *Philadelphia.*

MCCONVILLE, CURRAN C. (M) superintendent, Four Wheel Drive Auto Co., *Clintonville, Wis.*, (mail) P. O. Box 541.

MCELROY, JOHN J. (J) chief engineer, Sturtevant Aeroplane Co., Williams St., *Jamaica Plain, Mass.*

MCDONALD, E. G. (M) aeronautical engineer, Airplane Engine Division, Signal Corps, U. S. A., McCook Field, *Dayton, Ohio*, (mail) 911 Summers St.

MCINTYRE, W. J. (M) sales engineer, Splitdorf Electrical Co., 98 Warren St., *Newark, N. J.*

MCMILLAN, HORACE A. (A) draftsman, Chevrolet Motor Co., 618 W. 56th St., *New York*, (mail) 365 Edgecomb Ave.

MAYER, H. J. (J) mechanical draftsman, Holt Mfg. Co., *E. Peoria, Ill.*, (mail) Y. M. C. A.

METZGER, C. W. (A) salesman, The Haynes-Stellite Co., *Kokomo, Ind.*, (mail) Medford Hotel, *Milwaukee, Wis.*

MORRISON, H. A. (Aff. Rep.) superintendent of transportation department, The Scovill Mfg. Co., *Waterbury, Conn.*

MORRISS, PERCY G. B. (A) president, general manager, Bud Morriss Airplane School, Inc., 3511-3521 Lincoln Ave., *Chicago;* Naval Aviation Corps, U. S. A., *Washington;* (mail) Aviation Headquarters, Great Lakes Naval Station, *Great Lakes, Ill.*

MORGAN, E. TASSO (J) senior inspector, Breese Aircraft Co., Inc., *Farmingdale, N. Y.*

MOYET, EDMOND (J) designer, Andre Citroen Factory, 143 quai de Javel, *Paris, France*, (mail) 98 Boulevard Auguste Blanqui.

MURDOCK, JULIAN H. (J) tool designer, Robert T. Pollock Co., 68 Devonshire St., *Boston.*

MURPHY, WILLIAM T. (M) general manager, Standard Machinery Co., Elmwood Ave., Auburn, R. I., (mail) 164 Grand Ave., *Edgewood, R. I.*

MURRAY, J. J. (A) designer, Murray-Willat Motor & Aeroplane Corp., 15 W. 44th St., *New York.*

NOGLE, BYRON S. (A) automotive representative, Standard Oil Cloth Co., 320 Broadway, *New York.*

OHLIGER, LEWIS P. (J) research and specification chemist, U. S. Light & Heat Corp., *Niagara Falls, N. Y.* (mail) 321 1st St.

OSBORNE, ARTHUR D. (M) second lieutenant, Ordnance Reserve Corps, U. S. A., *Washington*, (mail) care Berrien-Durstine, Inc., 25 W. 45th St.,*New York.*

PALMER, JOHN OSBORNE (S. E.) student, Stevens Institute of Technology, *Hoboken, N. J.* (mail) 77 Highland Ave., *Glen Ridge, N. J.*

PICCIRILLI, P. A. (M) lieutenant, U. S. Navy, 2000 Elmwood Ave., *Buffalo.*

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Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

MILITARY AEROPLANES. By Grover C. Loening. Published 1918 by the author at 45 11th St., Long Island City, N. Y. Cloth, 6½ by 10 in., 202 pages, numerous line drawings and photographs. Price $4.75.

So many present day works on aviation deal with the subject from a popular or romantic viewpoint that it is a pleasure to announce the new edition of Mr. Loening's book which, although it is said to be written for the student aviator, is of the greatest value as an introduction to aeronautic engineering practice. The 1918 edition has been enlarged considerably and many new and valuable drawings and photographs added. Mr. Loening, now a member of the Aeronautic Division of the Standards Committee of the Society and also of the subcommittee on Engineering of the National Advisory Committee for Aeronautics, is of course eminently qualified to deal with the subject, in view of his long experience in the design and manufacture of aircraft.

In the preface the author states that he has endeavored to present all the essential technical features so that even a layman can understand them. The necessity for military censorship has made it impossible, of course, to include many details of new models and of advance flying technique. A good flyer should have a thorough enough understanding of the fundamentals of aviation, even though the personal equation is of vital importance. The book, therefore, proposes to furnish the student aviator with a knowledge of fundamental features, in order to aid him in acquiring the necessary instinct of what the machine is and what it is doing at all times.

The text is divided into fifteen chapters, the first three, about one-fifth of the whole book, relating to general types of aircraft, principles of sustentation and control of heavier-than-air machines (to which the book is principally devoted) and an outline of the necessary mathematics and mechanics required by the student in order to have a working conception of aircraft operation. Here the author takes the occasion to decry the vast amount of complicated mathematics often associated with the principles of the subject. Mr. Loening holds that much of this is built up on assumptions that the practical air pilot knows are erroneous. He does, however, give due credit to the valuable work done by aeronautic laboratories in advancing the art.

Practically half the contents are devoted to matters of direct engineering interest. The effect of air resistance on design, and the different types of aerofoils, or airplane wing sections and their characteristics are considered, as are such other fundamental elements of the machine as the propeller, stabilizer and controls. Then follows an important chapter on performance, giving examples of how lifting capacity, resistances, and the power required to fly are determined.

The logical way in which the subject is treated is illustrated in this chapter by the definition of an airplane. The author (page 11) has said an airplane consists of lift-generating surfaces attached to a frame carrying engine, fuel, pilot and equipment, and in combination with the devices to balance the craft. Now, however, after giving the reader information regarding resistances of different types of surfaces and their lifting efficiency, he gives a more technical definition as follows: An airplane consists of a combination of sustaining and balancing aerofoils with a lift determined by the values of the coefficient depending upon the shape of the surfaces presented by the machine to the air, speed of the machine, and its projected area; and with power suitably proportioned to overcome the head resistance of the structure, and the drift of the wings, at the expense of which the lift is obtained. The actual figures for lift, drift, etc., are calculated by the author in order to show the application of the theory, a machine being assumed in which the full load weight is 1800 lb., surface area, 335 sq. ft.; chord, 5 ft.; gap, 5 ft., and span, 36 ft. This same machine is used in the chapter on stresses and safety factors as an example in calculating stresses produced from the different members of the framework.

A short but interesting chapter is devoted to the special features introduced in the construction of aircraft for marine purposes. The effect of attaching pontoons or hulls to the aircraft is considered, as are the special elements in design introduced by the requirement that the whole machine must float on the water, must move through the water at an angle or hydroplane, and must be seaworthy to a high degree.

One of the most valuable chapters of the book shows the relation between the design of the machine and its qualities of stability or airworthiness when in operation. The chapter concludes with a summary as to what should be done to correct a number of different operating faults, these being due mostly to the incorrect location of the center of gravity of the machine or to the maladjustment of the control surfaces.

The average person has only a vague knowledge of just what happens in the special maneuvers that every aviator must be able to accomplish in order to take part in fighting. A number of cleverly worked-out diagrams illustrate the different positions taken by the machine in executing such "stunts" as the Immelmann turn, looping the loop, nose or tail spin, and also in other more common maneuvers, such as turning, climbing on turns and landing.

In the concluding chapter the author calls attention to the fact that while great attention must be paid to streamlines and aerodynamic efficiency, the first thing to seek in a flying machine is light weight, so that if there is any real basis of comparison at all between different machines, it is on a basis of weight per horsepower and weight per square foot of wing surface. The ingenuity and skill of the engineer officers connected with the aviation corps must be exerted to the utmost in compromising properly many opposing features. According to the author, high speed means reduction in load carrying capacity and often results in limitations of landing and starting. Facilities for observation and gun fire

(Concluded on page 54, advertising section)